Papers Presented at Eighth Ontario INDUSTRIAL WASTE Conference

JUNE 25th, 26th, 27th, 28th

1961

AT

Delawana Inn, Honey Harbour, Ontario

Sponsored By

THE WATER AND POLLUTION ADVISORY COMMITTEE

OF THE

ONTARIO WATER RESOURCES COMMISSION

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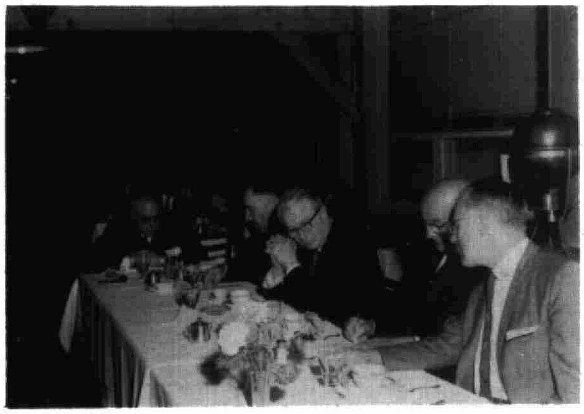

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EIGHTH ONTARIO
INDUSTRIAL WASTE CONFERENCE

1961

PREFACE

Dr. A. E. Berry
General Manager
Ontario Water Resources Commission
Toronto

Conference Chairman

The Eighth Ontario Industrial Waste Conference, sponsored by the Water and Pollution Advisory Committee of the Ontario Water Resources Commission, took place at Delawana Inn, Honey Harbour, Ontario, on June 5, 6, 7, and 8, 1961. An informative program of papers and discussions marked this Conference.

The Committee has endeavoured in all of these conferences to provide a medium of exchange of information among industrialists and all who are interested in the protection of the water resources of the Province. The proceedings of this latest conference are distributed as a contribution towards the dissemination of information gathered at this meeting. This publication contains valuable information on various methods of industrial waste disposal. It is hoped that the papers will prove valuable not only to those who were in attendance but to many others. The publication is made so that these papers can serve as a ready reference, and can be studied by a wide group interested in this subject.

The thanks and appreciation of the Water and Pollution Advisory Committee are extended to all who participated in these papers and discussions. Without such cooperation, no conference can be a success. The problem facing industry in the control of wastes is a great one, and the Water Resources Commission is glad to have the opportunity of assisting in this. The water resources of any country are one of its greatest assets, and by the full-hearted cooperation of all, it is feasible to carry on these industrial operations and, at the same time, protect the streams against undue pollution. The spirit of cooperation which has existed at the conferences has made it possible to achieve a great deal in the waste control program.

A list of those who attended the conference is enclosed along with the copy of the program and other relevant information.

For further information, write to the Water and Pollution Advisory Committee, Ontario Water Resources Commission, 801 Bay Street, Toronto 5, Ontario.

SESSION NUMBER ONE

C.S. MacNAUGHTON, M.P.P. HURON
Commissioner, OWRC,
Session Chairman.

TREATMENT OF ACID WASTES AND RECOVERY OF VALUABLE BY-PRODUCTS USING SUBMERGED COMBUSTION

by

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Chief Engineer,
Dakroe Ltd.,
Toronto, Ontario.

INTRODUCTION

The preparation of this paper has been with the permission and co-operation of J. Austin, B.Sc., A.M.I. Chem. Eng., Chief Engineer of Nordac Limited, who are considered the leading exponents in the world today on "Submerged Combustion" and its applications in chemical and waste treatment fields. Most of the actual operating facts and results are derived from the research and practical experience of Nordac.

Usually the actual chemical theory relating to the reactions in Submerged Combustion plants is quite simple, but to create the conditions for these simple reactions to take place, presents some of the most difficult problems imaginable in engineering. These have only been solved through considerable trials, tests and modifications over the last 30 years.

Later on I will demonstrate the chemical reactions on two typical acid pickle wastes; namely

(1) A Steel Company pickle liquor.

(2) A Copper Mill pickle liquor.

The treatment of acid wastes has always presented difficult conditions for industry, long before the authorities and public concluded that these wastes in particular are highly objectionable effluents.

Thus it is not surprising to find that extensive studies and treatment plants have been in operation as far back as 1891. However; no Industry invests capital in a non profit making operation if they can possibly avoid it, and as a result over the years only those wastes which indicate a saleable by-product from treatment have accordingly been treated, while those wastes which indicate doubtful and hopeless results of producing a profit remaim untreated.

Sulphuric Acid is one of the most important commodities of our modern industrial world. Millions of tons are produced annually. It is used directly or indirectly in nearly all industrial processes. In fact its rate of consumption is considered by many economists to be an accurate gauge of our national economy.

In this country over 1,000,000 tons are consumed annually and needless to say a good percentage of this Sulphuric Acid is converted into highly objectionable effluents.

Primarily I am only going to discuss methods of treating Sulphuric Acid wastes with "Submerged Combustion", because it is by far the biggest single acid waste, although I would like to mention that the same theories apply in principle to other acids and certain organic wastes.

Many Sulphuric Acid wastes contain metallic salts, i.e. Iron Sulphate, Copper Sulphate, Zinc Sulphate and Chromic Sulphate, etc., and these inorganic solutions all have their varying solubilities in water and acid, thus if they can be concentrated to a sufficient point, crystallization will take place, separating the metallic salt from the acid. At this point the acid can nearly always be used again and the metallic salt usually finds a use in another industry. It follows then if a highly efficient evaporator could be found, these acid wastes would become useful for conserving acid, producing metallic salts and turning embarrassing waste problems into profitable operations.

In Submerged Combustion, low cost evaporation can be achieved because the heat efficiency is in fact higher than any other single-effect, evaporation process, starting with oil or gas as fuel.

EVAPORATION OBTAINABLE FOR ONE LB OF OIL FUEL

System	Evaporation per lb oil
Boiler and Single-effect steam	12.0
Boiler and Double-effect steam	22.0
Submerged Combustion	15.5
Submerged Combustion + pre-evaporator .	22.3

TERMINOLOGY OF "SUBMERGED COMBUSTION"

If a gaseous or oil fuel is burned in a chamber partly submerged in a liquid so that the resultant products of combustion are released below the liquid surface, then the process is termed submerged combustion. The combustion products bubble to the surface, transferring the heat to the liquid. If sufficient heat is applied in this way, the liquid boils so giving rise to "Submerged Combustion Evaporation".

COMPARISON OF EVAPORATORS

Submerged Combustion is only one of serveral methods of evaporation using direct contact between liquor and hot gases and the object in all cases is to release the heat as closely as possible to the point where it is used.

A Submerged Combustion Evaporator in its simplest form is shown in Figure 1. The evaporator vessel, which is essentially only a holding tank, is fitted at one end with a duct for the outlet of the evaporated steam and residual gases, from the burner. At the other end, mounted in the cover, is the gas burner, the cylindrical combustion chamber being about half submerged. The lower end of the chamber is open, but the flow of gases prevents entry of the liquid. Gas and air are supplied, suitably pressurized, to a mixing head and thence to the chamber, where complete combustion occurs. The hot combustion gases bubble from the chamber, creating violent agitation of the liquid and, by the time these gases reach the surfgace, heat transfer is complete, the exit temperature being within 1°C of the liquid temperature.

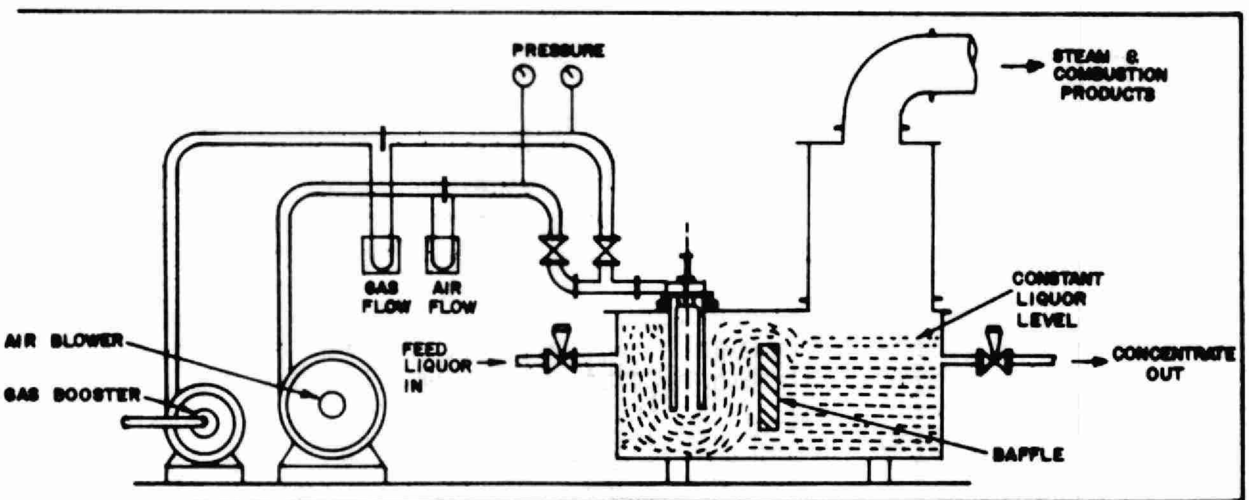

Fig. 1. Diagram of the submerged combustion evaporator in its simplest form

IMPORTANCE OF SUBMERGED COMBUSTION

High thermal efficiency was not, as it turned out, the main factor in the development of Submerged Combustion.

To evaporate dilute acid solutions presents the most corrosive conditions obtainable, especially at the points of transfer of heat into the vessel containing the liquid. In a "Submerged Combustion" plant the only part of the equipment faced with the full corrosive attack is the dip tube which carries the hot gases down into the liquor. This small part can be constructed of a cheap material, such as cast iron and regarded as a consumable item.

The evaporator vessel can be fully protected with acid proof brickwork, thus by elimination of costly stainless steel construction the capital cost of a Submerged Combustion plant lies well within the economics of a large number of acid recovery projects. And this, coupled with high thermal efficiency and increasingly lower rates for fuel in this country, offers profitable solutions to acid wastes.

TYPICAL EXAMPLES

Effluent liquor from titanium oxide manufacture varies, but a typical composition is 25% H_2SO_4, 8% $FeSO_4$. Most pickle liquors are about 10% H_2SO_4 and 17% $FeSO_4$. If these effluents are concentrated, the solubility of ferrous sulphate decreases until at about 50% H_2SO_4 its solubility is only 2%. The ferrous sulphate thus separates, forming under these conditions, crystals of monohydrate ($FeSO_4 IH_2O$) which can be separated from the acid. The free acid is then available for re-use in the case of pickling, or for further concentration in the case of titanium liquors.

Since in these sulphuric acid wastes the metallic salt is a sulphate it follows that when the sulphuric acid strength is increased the sulphate ion (SO_4) supersaturates the solution thus making the sulphate salt insoluble.

To illustrate the phenomena take a sample of pickle waste containing 8% H_2SO_4 and 15% $FeSO_4$ and add concentrated H_2SO_4. When the solution is over 50% H_2SO_4, the $FeSO_4$ will be seen to crystallise. Obviously we cannot do this in practice because we would be steadily increasing the volume of liquor to unmanageable proportions, thus the only economical and practical way is to evaporate the water and build up the concentration accordingly, however; the experiment serves as quick proof to the reaction.

A very important aspect of the above is that ferrous sulphate monohydrate, unlike copperas, $FeSO_4\ 7H_2O$, can be roasted to give SO_2 and ferric oxide, the SO_2 being converted to sulphuric acid and the ferric oxide can be used in the Sinter Plants of Steel Works. Thus in this case the effluent problem is 100% solved and a wastage of raw materials prevented.

EXAMPLE #1

Spent Pickle from Steel Mills

Figure 2 is a basic flowsheet for a Submerged Combustion plant for concentration of spent pickle acid to 50% H_2SO_4 with a separation of monohydrate. The weak liquor enters at about 80°C into the special heat exchanger, called the "Pre-Evaporator". This uses the heat from the evaporator exhaust gases by transmission through lead tubes to the pickle liquor, which is circulated over the outside of the tubes. The temperature gradient for heat transfer is maintained not by vacuum operations but by evaporative cooling, wherein large volumes of air are drawn over the outside of the tubes. This evaporative cooling keeps the liquor at about 45°C on the outside of the tubes, the exhaust gases on the inside being saturated at 83°C at entry and leaving at about 60°C. The pre-concentrated liquor, now nearly saturated with ferrous sulphate, enters the evaporator, where the acid is maintained at 50% H_2SO_4, boiling at 110°C under submerged combustion conditions. Monohydrate crystals form in the evaporator and are removed continuously as a thin slurry. The slurry is delivered into a conical sedimentation vessel where the crystals settle, with the excess of acid overflowing back to the evaporator vessel. Part of the acid is drawn off as production acid and is returned to the pickling process. The lower part of the settling vessel is fitted with a jacket to cool the thickened slurry, before it is fed to a continuous centrifuge. This centrifuge is of the pusher type and is fitted with three coaxial baskets. Separation is effected by slotted sieves, while the crystal cake is pushed along from one basket to the next by the reciprocating motion of the first and third baskets relative to the second.

During its passage through the centrifuge, the cake is washed with a small amount of warm water and emerges with about 2% of residual acid content.

The second stage of this effluent, the conversion of the monohydrate to H_2SO_4 requires a monohydrate very low in residual acid and free water, and it is on the solids-separation side of these plants that development work is now proceeding.

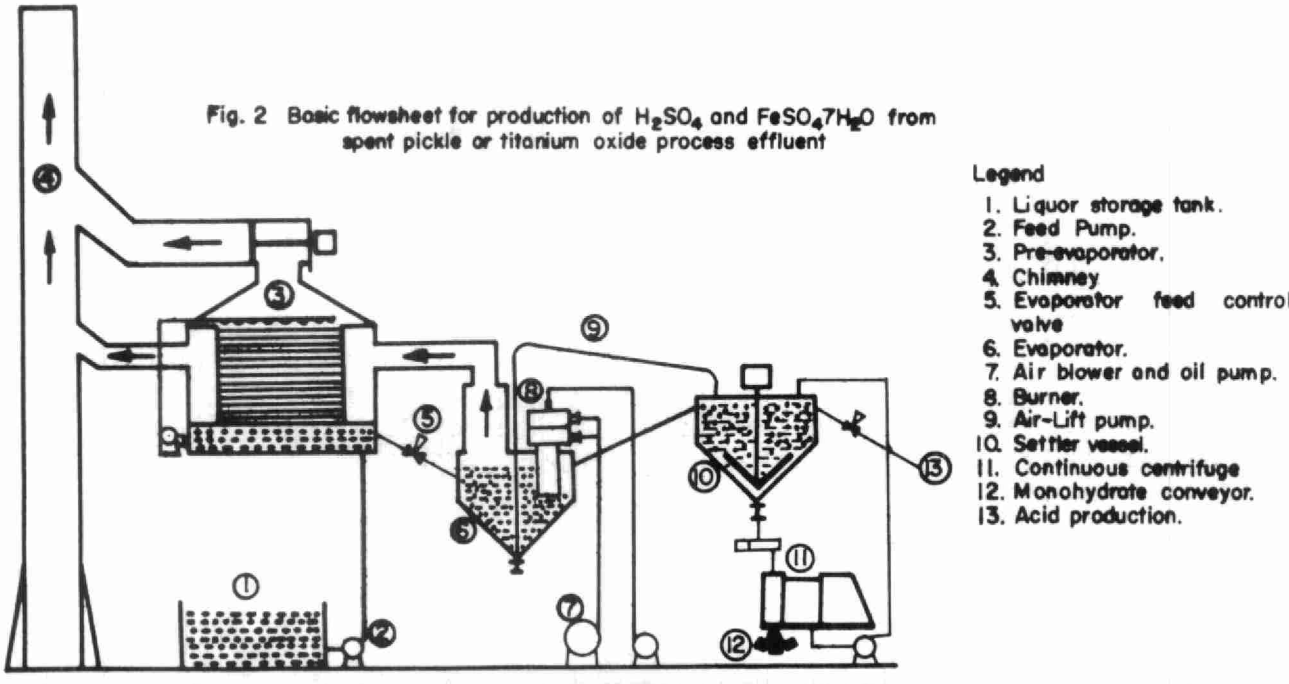

Fig. 2 Basic flowsheet for production of H_2SO_4 and $FeSO_4 7H_2O$ from spent pickle or titanium oxide process effluent

TABLE 1 - Data for Submerged Combustion Plant Treating Waste Pickle Liquor (Mean Hourly Figures)

	lb/hr.	Composition
Spent Pickle	16,900	9.7% H_2SO_4, 16.5% $FeSO_4$
New Acid added to replace $FeSO_4$	2,340	78% H_2SO_4
Acid returned to Pickling Plant	7,150	42.7% H_2SO_4, 3.2% $FeSO_4$ (after slight dilution)
Monohydrate removed	3,000	2.4% H_2SO_4, 7% H_2O
Evaporation (total)	9,300	
Oil Consumption	418	Gas oil
H_2SO_4 reclaimed	1,420	As 100% H_2SO_4

Evaporation per lb of oil.	
- Evaporator	14.0
Pre-Evaporator	8.3
	22.3

Heat usefully employed per unit gross heat input = 1.37

EXAMPLE #2

Spent Electrolyte from Nickle refining

Spent electrolyte can contain a typical analysis as follows:

1.0	gm/l	Copper
6.0	" "	Iron
20.0	" "	Nickle
350.0	" "	H_2SO_4

This is concentrated and separated to give crystals containing 50% nickle sulphate (Ni SO_4 H_2O) which is sold for purification and also a recovered electrolyte of:

65%	H_2SO_4
0.7%	$NiSO_4$
0.5%	$FeSO_4$
0.4%	$CuSO_4$

which is returned to the cells.

Many other applications are:

1. Pickle Waste
2. Titanium Waste
3. Spinning Bath Solutions
4. Contaminated electrolyte
5. De-nitrated acid
6. Hydroxylation Acid
7. Organic chemical process acid
8. Concentration of phosphoric acid
9. Stripping of Hydrochloric acid from solutions
10. Concentration of fish and whale stickwater
11. Concentration of salt solutions, i.e. $CuSO_4$, $ZnSO_4$ etc.
12. Concentration of Distillery wastes for cattle feed
13. Dehydration of Glauber's salt.

The economics of Submerged Combustion starts with the concentration of the contaminant in the waste. For example; the above cases were related to really concentrated wastes of 8% H_2SO_4 and 15% metallic salts which in OWRC terminology of units of measurement is 80,000 p.p.m. H_2SO_4 and 150,000 p.p.m. metallic salts and when this is compared against by-laws referring to maximum contaminants of 5 p.p.m. etc., the potency of the waste is readily appreciated. However, to get back to the economics, we usually consider only those wastes that contain over 1% to 2% metallic salts worth considering for recovery with submerged combustion.

In practice acid wastes usually fall strength wise into two main headings:

(1) High Strength Wastes.
(2) Low Strength Wastes.

and there is a very wide gap between these two strengths, because they are formed as a result of two separate operations.

"High Strength" acid wastes are usually formed by dumping of spent acid pickling tanks and "Low Strength" acid wastes are usually formed by rinsing a pickled product clean of acid after passing through a pickle tank.

During the course of a years operation of pickling as much as, or more, acid and metallic salts are dumped with the rinse waters, as is dumped from the main spent acid pickling tanks. The strengths of these rinse waters vary from 30 p.p.m. acid and metallic salts to over 100 p.p.m.

This strength although vastly lower than the main pickle waste, (i.e. 1,000 times diluted) still is many times above the accepted standards stipulated in the regulations. In the past most Companies faced with purification of rinse waters are confronted with heavy financial burdens if neutralization with such chemicals as caustic are considered, (especially if they have to pay for water). Research is progressing at a fast pace on "Ion Exchange".

Ion Exchange only works on very dilute solutions of the order of 400 p.p.m. and below.

Thus if a rinse water, containing say, 100 p.p.m. $CuSO_4$ were placed through a suitable Ion exchanger unit, the result could be pure mineralised water as the effluent which is immediately reusable and a solution of $CuSO_4$ approximately 5% (50,000 p.p.m.) which is ideal for concentration by Submerged Combustion to produce copper sulphate crystals ($CuSO_4\ 5H_2O$), the basic commodity for many in dustrial processes.

Again this is a near perfect and useful process which eliminates a pollution problem by producing and saving raw materials: unfortunately, I have not come across this application in practice yet, but I understand from well informed sources that work is proceeding on this aspect of the problem.

To conclude this paper I would like to point out that many chemical processes are in fact recovery processes on another industry's waste product. One of the simplest ones which comes to my mind is the Sulphuric Acid Plant of C.I.L. located at Copper Cliffe, Ontario, which derives its raw material of SO_2 from the spent gases passing up the main stack of International Nickle Company's main smelter. The large chemical concerns spend millions of dollars working on processes to recover chemicals from waste products which in turn eliminate pollution sources. Unfortunately their work has to stop when a project does not show a fair return for the investor's capital. At this point it is up to the company itself to find an answer to its waste problem and more often than not they do not have the personnel available with the right experience because waste treatment is far removed from the main purpose the company is engaged in for its livelihood and existance. However, it is to be expected that in the near future more thought and effort will be applied to the problem of recovery of valuable by-products from industrial wastes.

One last thought on wastes: I believe that much can be done to encourage profitable waste treatment by going back to the economist's basic principle of "Supply and Demand". Good government should help foster demand and industry will supply this demand. An example of this is possibly $FeSO_4$. If all the steel pickle liquor was treated, as outlined above, there would be available in excess of 30,000 tons per year of $FeSO_4$. A recent survey shows that there is only a market in Canada for 7,000 tons of $FeSO_4$. But if $FeSO_4$ was used as a coagulant in sewage plants, there would be an increase in demand for supply of an additional 700,000 lbs. (350 tons) per million people using sewage plant facilities.

MILL WASTE DISPOSAL SYSTEM AT THE TERRACE BAY, ONTARIO MILL OF THE KIMBERLY-CLARK CORPORATION

by

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Technical Department,
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Terrace Bay, Ontario.

The Kimberly-Clark policy with regard to the reduction of stream pollution, is to minimize water pollution as technically and economically sound methods become available. It is expected that the mills within the Corporation will contribute to the program and be alert to possibilities for change and development which will abate stream pollution, and will take action on these possibilities. To control pollution and to operate the mills in conformance with laws, orders and policies requires that a regular system for measuring discharged wastes be established and maintained and that necessary action be taken to maintain the established control.

Measurement of sewer effluent flow in the Terrace Bay Mill was anticipated in the original design. A tile-lined Parshall flume was installed in the main mill sewer, and smaller Parshall flumes were built into the two main tributaries. (the evaporator and washer sewers). The pulp mill sewer layout is shown in Figure 1.

A flow meter and a gear-type sample pump were included for the main sewer flume, with metering and sampling on the other two left for later development. It was quickly evident that the gear-type sample pump would not operate satisfactorily on an effluent containing woodroom wastes. Much time and effort were spent in design and redesign of a satisfactory effluent sampler.

Finally, a sampler, composed of a sample cup pushed into and withdrawn from the effluent stream by a pneumatic cylinder with suitable stroke, was designed and installed at the main sewer Parshall flume. After some difficulties, the cylinder operated sampler was made to work satisfactorily and similar devices were then installed at the two remaining flumes.

The automatic sewer sampler, sample cup and hanger are shown in Figures 2 and 3.

The main sewer flowmeter is actuated by a float in a stillwell connected to the Parshall flume. The evaporator and washer sewer flowmeters are actuated by bubble pipes, in stillwells, connected to sample points in the Parshall flumes. Air, reduced in pressure to 17 p.s.i., flows to the main sewer transmitter unit. This unit releases air, at a varying pressure of 3 - 15 p.s.i., to the flow recorder. The pressure of the air released from the transmitter unit is dependent upon the level in the stillwell and the float position. The integrator on the recorder has suitable contacts to throw a microswitch and energize a relay every 10,000 gallons of effluent through the main sewer, in order to operate the sampling device. At intervals of 3,000 gallons through the evaporator and washer sewers, the integrators close contacts to actuate the samplers on these tributary sewers. Shift samples are collected from the box containing the gross samples of effluent from the main, evaporator and washer sewers. A piston-operated sampler can be made to take a composite sample proportional to flow, even from effluent containing solid material.

The general location of the waters receiving mill effluent and the surrounding land area is shown in Figure 4. The mill is located near the lower end of the Aguasabon River. The natural drainage of the mill property is to Beaver Creek, a tributary of the Aguasabon River. Mill wastes are discharged through an open ditch, constructed by Kimberly-Clark, to Blackbird Creek. After passing through two lagoons (lagoons 'A' & 'C'), the creek discharges into Lake Superior at Moberly Bay. Blackbird Creek is approximately 17 miles long and is crossed by Highway 17 in three places and by the C.P.R. once, at Moberly Bay. The creek is quite turbulent for most of its course.

It must be quite apparent to all that the Terrace Bay mill has a fortunate geographic location and that the natural resources of the area are utilized to the fullest to dispose of the pollutional material in the mill effluent. This did not just happen, but resulted from a careful survey of potential mill sites along the north shore of Lake Superior. Several proposed areas of development were studied and rejected for various reasons, until finally, the present land area was selected for mill and townsite development. There is little doubt that the natural waterway, starting quite near the new mill site and discharging into Lake Superior, was a factor of great importance in the final selection and approval of the present area, for mill and townsite development.

It has been stated that only one of the factor requirements, important to maintain a satisfactory aquatic habitat, is affected by wastes from the Pulp and Paper industry; namely, dissolved oxygen. It is this dissolved oxygen requirement that is the basis of the most important stream improvement problem facing our industry. Other factors involved are temperature, turbidity, carbon dioxide, pH and siltation.

The solids content and toxicity of the mill wastes are two other factors that promote concern in our industry, in relation to

their effect on the aquatic habitat. These, however, are of less importance than oxygen depletion. We are, indeed, fortunate to have located a mill site and waste disposal system where the mill wastes have no discernible effect on the receiving water; in this case, Lake Superior.

DISSOLVED OXYGEN & BOD:

In a body of water, the size of Lake Superior, with its low temperature and high oxygen content, the total withdrawal of oxygen because of waste material is insignificant. The important thing is to know the degree to which oxygen is consumed in the vicinity of the creek outlet and to delimit the area where aquatic life would suffer from oxygen deficiency. Our techniques of testing are based on these considerations, and are designed, we think, to provide the most practical information.

By definition, the biochemical oxygen demand is the oxygen required to stabilize the decomposable organic matter by aerobic bacterial action. The procedure used to determine the BOD of the mill effluent is a procedure known as the Winkler method.

The summer water temperature at the mouth of Blackbird Creek is lower than the 20 degrees Centigrade incubation temperature, so the withdrawal of oxygen would be slower than that indicated by our incubated samples.

Our results are, therefore, higher than that which would actually be demanded from the receiving waters over a 5-day period.

BIOCHEMICAL OXYGEN DEMAND-ppm
(Average for year 1959)

Source	Summer (May-October)	Winter (November-April)	Yearly Avr.
BOD of effluent leaving mill	150	135	145
BOD of effluent at point of discharge into receiving water. (Lake Superior)	60	No Tests	Estimated less than 60

The % reduction in BOD between the mill and receiving water is calculated as 60%, range 50-70%.

Dissolved oxygen may be added to water by several means, such as re-aeration, sufficient stirring to create vortices, dropping effluents over weirs, passing effluents over rapids, dilution and even wind velocity and wave height.

In a section of Blackbird Creek above lagoon 'C', poles have been laid across the creek at intervals and anchored to either side by means of cables. These poles function as cascades, producing a small turbulance, in an effort to aerate the effluent.

Below lagoon 'C' are turbulent rapids and falls which further aerate the effluent, but, in so doing, some foam is produced.

To contain the foam and to prevent it from floating out into Moberly Bay, three foam barriers, located at the bottom of the rapids and falls and spaced at intervals of approximately 50 feet, are maintained. Each barrier is actually a log boom, anchored with cables on either side of Blackbird Creek. This method of containing the foam has worked very effectively in eliminating the escape of any of the foam produced by the turbulent flow of the creek, between the outlet of lagoon 'C' and Moberly Bay. The foam eventually dries out, due to the retention time offered by the barriers, and is destroyed by the action of the wind.

Although the foam would not be at all damaging to the aquatic life, if the total amount produced were allowed to escape into Moberly Bay and Jackfish Bay, it does present somewhat of an eye-sore and could cause some comment by rail travellers. It is at this point that the C.P.R. transcontinental line crosses Blackbird Creek. Public relations, regarding pollution, is therefore recognised as being of great importance.

The 60% reduction in BOD is effected in Blackbird Creek by aeration and dilution, with the added dilution afforded by Moberly Bay and Jackfish Bay completely eliminating the remaining BOD.

REMOVAL OF SUSPENDED SOLIDS:

The effect of ponding, or lagooning, is to withhold the suspended material and to prevent a continuing BOD from developing in the receiving waters. Lagoons cannot be expected to bring about a reduction in BOD if they function as settling basins for suspended solids. In assessing the value of a lagoon, the absolute BOD of the solids it withholds must be considered. From this point of view, a small increase in the BOD of the outlet water is insignificant compared to the total discharge of solids if the lagoon did not exist. Mill control is exercised to minimize the loss of solids at the source by installing new equipment where necessary, and by making the most effective use of present operating equipment.

Presently, mill effluent is emptying into the South end of lagoon 'A'. where the water is approximately 20 feet in depth. This lagoon originally covered 47 acres of land area, but since mill start-up in 1948, the area under water has been reduced by approximately 44%, or, there are approximately 26 acres of submerged land area remaining for further utilization. The greatest volume of deposition occurred during the mill start-up period and for several years afterwards until a closer control over the loss of solids was initiated at the mill. This control has resulted in an extension of the useful life of lagoon 'A' in removing the pollutional material in the effluent stream, by sedimentation.

There still continues to be, as it has been since mill start-up, 100% sedimentation in lagoon 'A', the first of the two natural sedimentation basins, in our disposal system. Results of a survey

of lagoon 'A' in 1959 show that approximately 3,640,000 cu. ft. are still available for effective removal of the pollutional material in the mill waste stream, or, the remaining useful life of lagoon 'A' has been estimated to be a minimum of 10 more years.

The second lagoon, identified as lagoon 'C', in the mill waste disposal system is actually two lagoons divided by a short, shallow channel. The upper lagoon has a maximum depth of approximately 21 feet. The total length of lagoon 'C' is 1-1/4 miles from inlet to outlet, and covers a land area of 69 acres. Bottom samples are collected, twice yearly, from the upper lagoon and examined for fibre. No sedimentation, resulting from mill operations, has been detected in any of these samples.

LAGOON MAINTENANCE:

The important function of the first natural lagoon, in removing the suspended solids load, cannot be over-emphasized and yearly maintenance along the banks of Blackbird Creek, at its outlet into lagoon 'A', is carried out.

The high water level in the spring usually causes damage to the influent channel at lagoon 'A'. The mill effluent channels several new courses along the creek bank, and in so doing, by-passes most of the settling area in the lagoon. When normal flow levels are reached, mill structural crews repair and reinforce the damaged areas of the creek bank to redirect the effluent flow to fully utilize the available area for sedimentation. Actually, the outlet of Blackbird Creek, at lagoon 'A', has been relocated three times in order to do this.

STREAM IMPROVEMENT:

Improvement in conditions existing in Blackbird Creek, along its entire course, is accomplished by -

A. Installing new equipment where necessary, and making the most effective use of present operating equipment, to minimize chemical and solids losses at the source, and

B. Maintaining the waste disposal system to fully utilize the two natural lagoons, for removal of the pollutional material by sedimentation, and to withhold the foam created near the outlet of Blackbird Creek, at Moberly Bay, by the turbulent flow over rapids and falls.

EQUIPMENT INSTALLATION TO MINIMIZE CHEMICAL AND SOLIDS LOSSES:

Since 1949, the following installations were completed. Most were approved exclusively for the abatement of stream pollution and two systems were installed for reasons of economic return, but have also resulted in stream improvement.

A. <u>MAJOR INSTALLATIONS AND EXPENDITURES EXCLUSIVELY FOR THE ABATEMENT OF STREAM POLLUTION</u>

1. <u>Rotary drainer</u>, for the removal of barking refuse from the woodroom effluent. This system recovers approximately 30,500 tons of bark per year, with a fuel value of $90,000. The fuel recovery value, however, is not as economical as other fuels.

2. <u>Soap recovery system</u>. In the operation of a modern day Kraft mill, a rigid control of losses of skimmed soaps is maintained. To eliminate these losses, a soap recovery system was installed. The soap is presently sold for further processing, but may also be fired in the recovery furnace to derive its chemical and heat value.

3. <u>Recovery of effluent from the operation of the Knot Rejects System</u>. The chemical loss to the mill waste disposal system is eliminated.

4. <u>Extension of the culvert at the first creek crossing of Highway 17</u> and landscaping the area on the south side of the Highway, to restore the aesthetic value of the area for the travelling public.

5. <u>Yearly maintenance of the waste disposal system</u> from the mill to the outfall at Lake Superior.

B. <u>MAJOR INSTALLATIONS FOR REASONS OF ECONOMIC RETURN, BUT THAT HAVE ALSO RESULTED IN THE IMPROVEMENT OF STREAM CONDITIONS.</u>

1. <u>Turpentine recovery</u>. The crude turpentine production nears 202,000 U.S. gallons per year. The product is marketed for an annual net value of approximately $29,000, or, fired in the recovery furnace.

2. <u>Knotter and Screens rejects reclaim system</u>. This system returns an approximate total of 15 ODT per day to the pulp system. (7 ODT from the screens and 8 ODT from the knotters.)

<u>SYSTEM TESTING PROGRAM</u>:

In order to evaluate an operational change or equipment installations, it is necessary to audit the regular system for measuring discharged wastes and to maintain a system testing program.

TESTS PERFORMED:

Our techniques of testing are designed, we think, to provide the most practical information, and a summary of the tests performed follows.

1. Dissolved Oxygen and BOD

The BOD of the combined mill effluents (main and bleachery sewers) is determined weekly on composite samples, which are obtained proportional to flow.

During the summer months, (May to October) the BOD of the effluent in Blackbird Creek, approximately 50 feet above its outlet into Moberly Bay, is determined twice monthly. The BOD test is also performed twice monthly on water samples collected in Moberly Bay between -

a) Bennett Island and the east shore, and
b) Cody Island and the west shore.

The effect of the effluent on the receiving waters is limited to an area of approximately 1/4 square mile in Moberly Bay. Although the mill has been operating for 12 years, there is no evidence that this area is likely to expand.

2. Suspended Solids

The main and bleachery sewers are sampled separately, proportional to flow, and analyzed for total and suspended solids and fibre. The results are reported daily and expressed as pounds of discharge per day.

Grab samples of the effluent at the outlet of lagoon 'A' are obtained weekly and analyzed for total and suspended solids and fibre. This sample point is located at the second crossing of Highway 17 by Blackbird Creek.

3. Color

Biologically, color is not too important, but aesthetically it is.

During the regular boat trips to the sampling stations in Moberly Bay, several traverses are made of the Bay to collect water samples for a color determination, in an attempt to define the outer limits of the effluent-spread in the Bay. In this case, wind intensity and direction are important factors in defining the outer limits of the measurable effects of the effluent, by color.

Results obtained from this color test are plotted on a large map of Jackfish Bay and areas having the same color, as shown on the spectrophotometer, are shaded with different

colored pencils. The use of the spectrophotometer, for light transmission work, permits a very accurate delineation of the effluent spread, in Moberly Bay.

The outer boundary of the spread of effluent has been checked for several years, both by direct observation of color and by % transmittance of light. Although considerable fluctuation takes place, as a result of wind direction and intensity, the average position of the boundary at a particular date is remarkably constant.

The outer boundary of mill effluent effects is shown in Figure 5.

An early attempt was made to plot the under water temperature gradients. It appeared that very little mixing occurred below the isotherm for 10 degrees centigrade and most of the effluent moved outwards and upwards along the isotherm for 11 degrees centigrade. Where no mixing occurred, the isotherms remained constant.

SUMMARY:

1. Effective and steady progress is being made to improve stream conditions by installing new equipment, where necessary, by making the most effective use of existing plant equipment to minimize chemical and solids losses at the source, and by maintaining the mill waste disposal system to fully utilize the two natural lagoons for removal of the pollutional material by sedimentation.

2. Conditions in the receiving waters (Moberly Bay) are satisfactory, as shown by records of dissolved oxygen and BOD.

3. The regular system for measuring discharged wastes is carefully audited and a system testing program is maintained.

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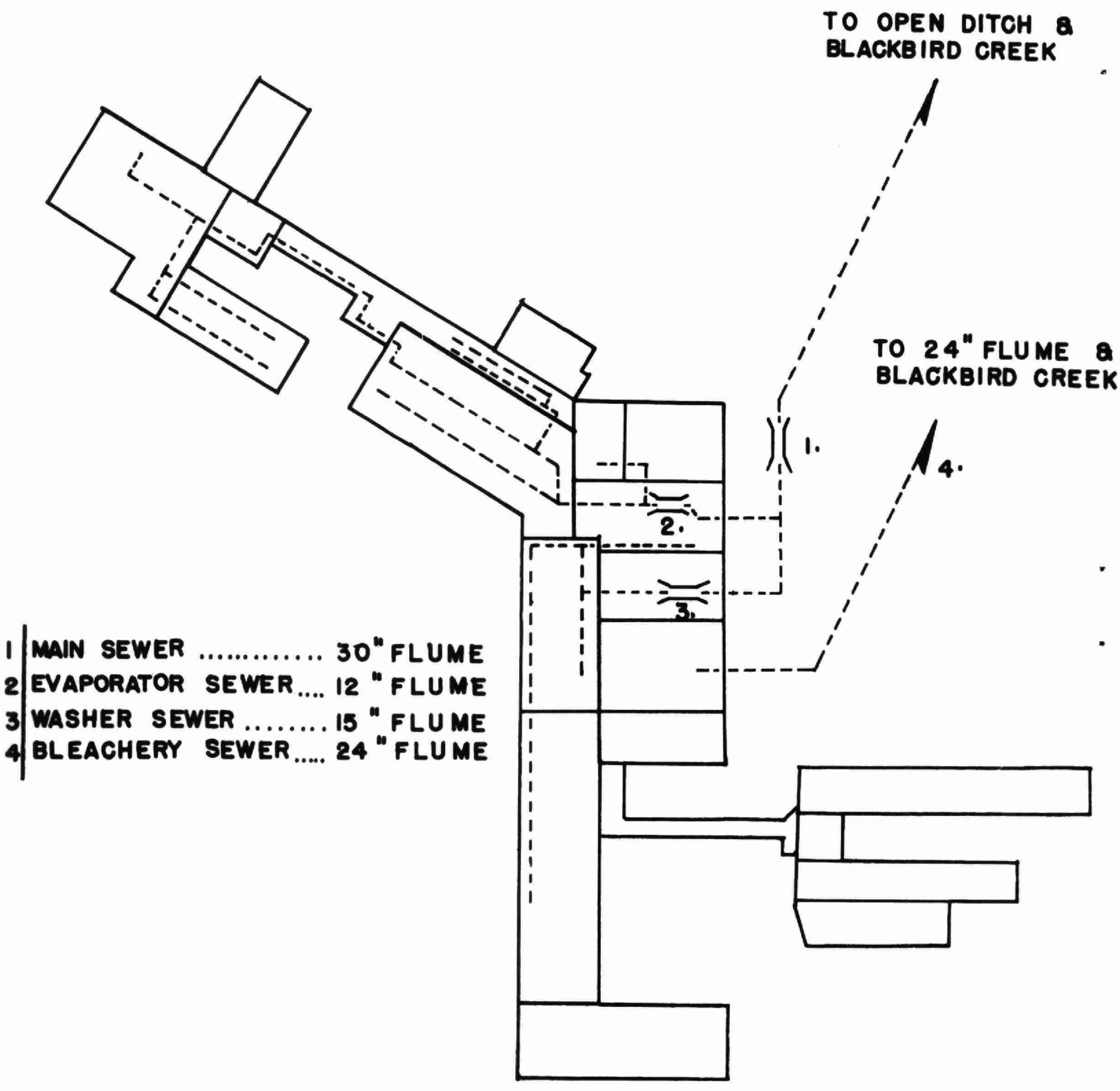


FIGURE 1. PULP MILL SEWER LAYOUT SHOWING LOCATION OF PARSHALL FLUMES AND FIXED SAMPLING STATIONS.

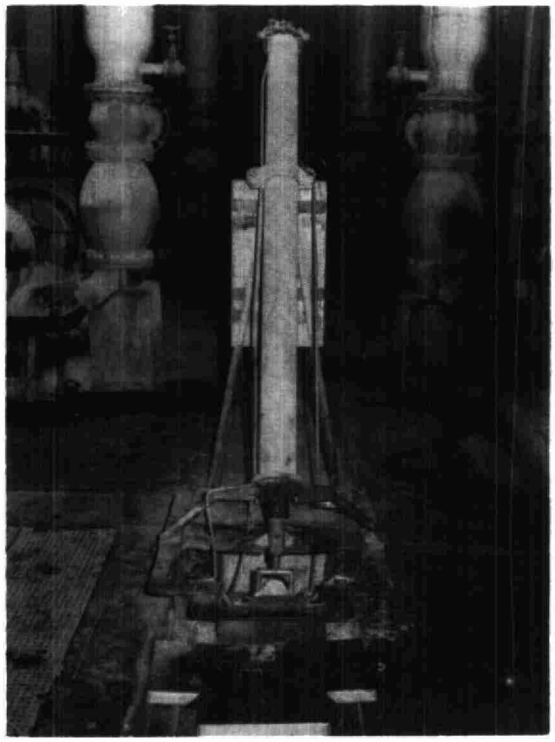


FIGURE 2. AUTOMATIC SEWER SAMPLER AT WASHER SEWER, SHOWING PNEUMATIC CYLINDER, SAMPLE CUP AND HANGER IN TRIPPED POSITION.

FIGURE 3. SAMPLE CUP AND HANGER SHOWN IN TRIPPED POSITION.

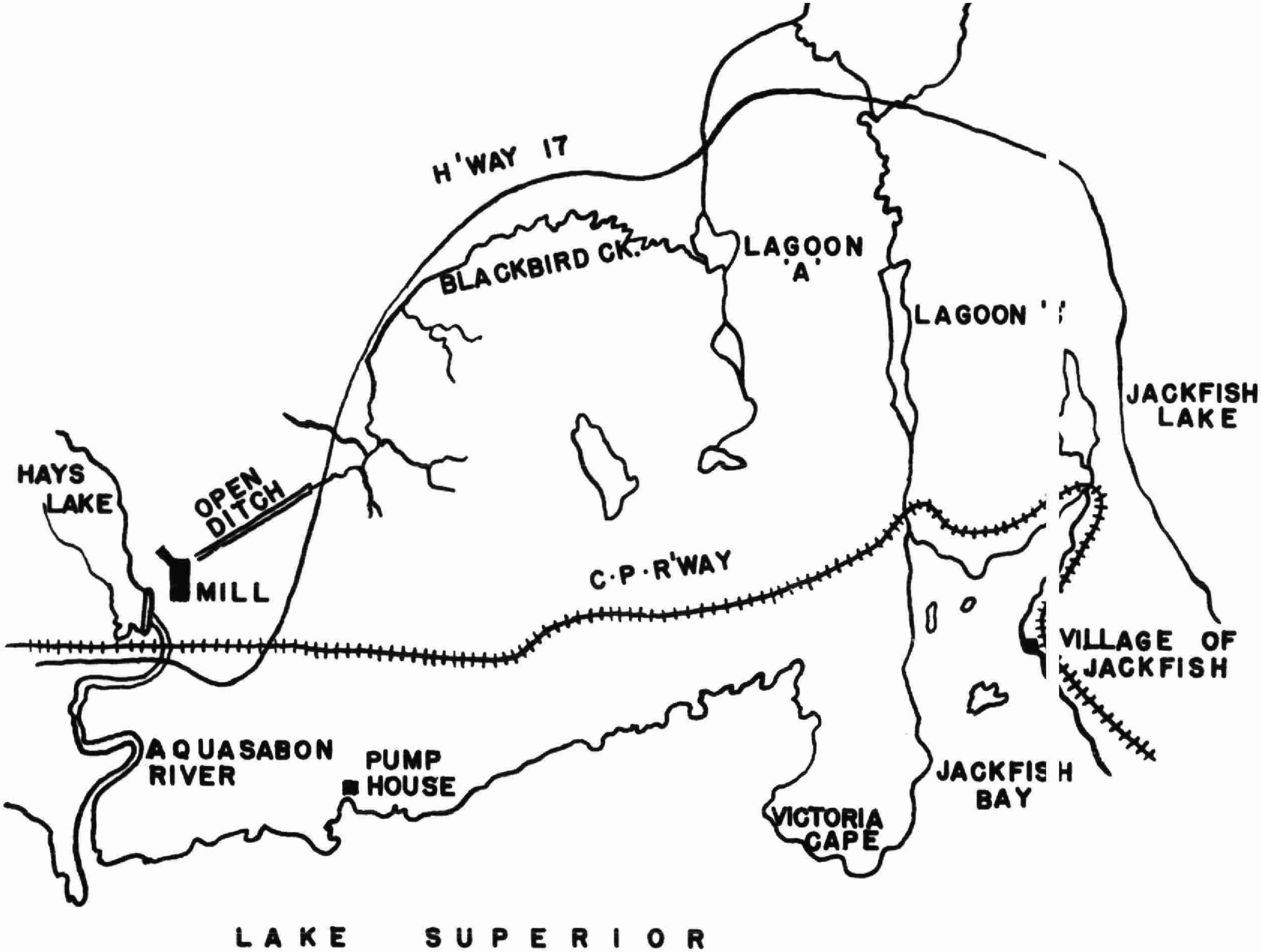
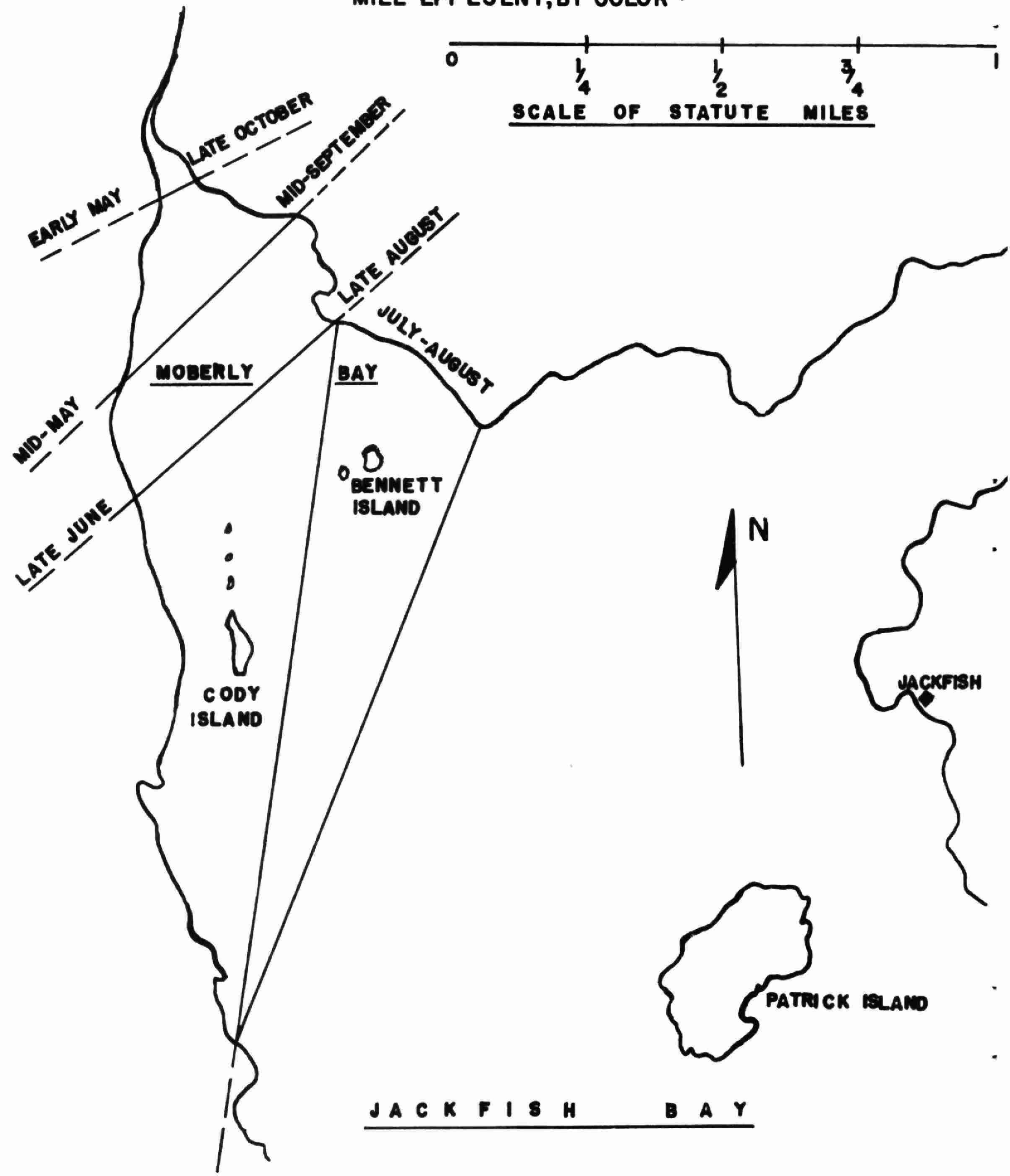


FIGURE 4· MILL WASTE DISPOSAL S''STEM

FIGURE 5. MOBERLY & JACKFISH BAYS, SHOWING THE AVERAGE POSITION OF THE OUTER BOUNDARY OF THE MEASURABLE EFFECT OF THE MILL EFFLUENT, BY COLOR.



CONFERENCE DELEGATES

SESSION NUMBER TWO

C. F. GURNHAM,
Editor,
Industrial Water and Wastes.
Session Chairman.

MANAGEMENT OF RADIOACTIVE WASTES AT A NUCLEAR POWER PLANT.

by

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INTRODUCTION

Canada is about to enter the field of generation of electric power from the energy produced by nuclear fission. We have a great deal of experience in this country in the operation of research and development reactors - in fact for many years the NRX reactor at Chalk River had the highest neutron flux in the world and certain experimental work on reactor components could be carried out in NRX more efficiently than anywhere else. The powerful NRU reactor provided a further advance in experimental and research facilities which have been used on an international scale, and our reactors have produced a high proportion of the cobalt-60 for the world's supply of gamma-ray therapy units. However; up to now the heat energy produced by the reactors at Chalk River - at a rate of about 250,000 kilowatts - has been largely wasted, as most of it finds it way into the cooling water returned to the Ottawa River.

The first of our power reactors, NPD, will probably be operating before the end of this year. It is situated at Rolphton, about twenty miles upstream from the Chalk River Atomic Energy Establishment and about twelve miles upstream from Deep River, where many of the staff of Atomic Energy of Canada Limited have their homes.

NPD will be a small demonstration reactor, developing 20,000

kilowatts of electrical power, which will be fed into the grid serving-among other places - the metropolitan area of Toronto. Many of the lessons to be learned about the design of heavy water, natural uranium nuclear power generators were provided during the conception, design and building of this reactor. The necessity for learning-by-doing was recognized from the beginning, and the solution of the many problems that arose during the development of NPD has made it possible to hope that, when the first of our large power stations is built, it will come much nearer to economic competition with stations deriving their energy from fossil fuels.

In a rapidly developing field of engineering it is not practicable to wait for results from one design before starting on its successor. Design work on the full scale station, "CANDU", near Kincardine, was started before ground was broken for NPD, and concepts for more advanced reactors are already under active development. Technology in this field advances so quickly that a design can seldom be "frozen" until the steel, concrete and other materials are irrevocably in place. Even then a calculation by a nuclear physicist, or the result of a test irradiation of a part of the complex mechanism of the reactor, may necessitate changes in the completed structure.

In the field of environmental safety, including water pollution, a somewhat similar situation exists. Ideally, one should know the amount and nature of all radioactive material that could be liberated into the environment from the plant under all credible conditions both of normal operation and of accidental release. One should have an exact knowledge of all the mechanisms for dispersion of this material, such as winds, water movement, ground-water seepage and movement of contaminated organisms. One should also know the usage to which man puts his environment, either directly or indirectly - for example whether water is used for drinking, watering cattle, breeding fish, swimming or making paper to be used in photography. Alternatively, it may not be used for anything that could conceivably transfer the effect of radiation to man. In order to establish a figure for the maximum permissible concentration of a contaminant in water, we must know what the water is used for, and the use can make a very big difference to the limit that is set.

Complete information of this kind never exists and is extremely difficult to obtain. The design engineers have great difficulty in forecasting the magnitude of leakage from the plant and they apply such large safety factors in their calculations that the results usually prove they have been unduly pessimistic. This was strikingly shown at the Shippingport power reactor in the United States (1). The biologists who estimate the effects of the release on man do not credit the engineers with having thrown in any safety factors, and they apply a few of their own, so the biological forecast is also pessimistic. This is well illustrated by experience with the Windscale pipeline for disposal into the Irish Sea (2).

It is just as well that this multiplication of caution leads to what looks to the economist like over-emphasis on costly safety measures. The general public, and many scientists, are far more alarmed about radiation than by any other hazard.

The routine slaughter on the roads, crashing aircraft, the collapse of a bridge or a gas explosion, have little impact on the public. No demand arises for the abandonment of activities leading to this kind of hazard. Yet millions of dollars and the work of thousands of highly qualified people are devoted to the detection and recording of radiation from weapons fallout, which is only a small fraction of the natural radiation from radium in the earth and cosmic rays from the heavens. These radiations have impinged on man from the earliest stages of his evolution.

Much of the effort that goes into the safety aspects of nuclear energy is devoted not only to ensuring real safety but also to convincing a sceptical public that things really are safe. For example, the dilution factors in the Ottawa river are so large, and drinking water intakes are so far away, that we at Chalk River could put much more radioactivity into the river than we actually do without exceeding the maximum permissible concentration laid down for water by the International Commission on Radiological Protection. However, such action would be ill-advised. Fish, among other things, concentrate such essential elements as phosphorus and zinc very efficiently from the water. Phosphorus-32 and zinc-65 are among the radionuclides that occur in our reactor cooling water, and they are concentrated in the fish. We have to make sure that the fish contain practically undetectable amounts of radioactivity, in spite of the fact that the most enthusiastic sport fisherman is unlikely to eat more than a pound or two of Ottawa River fish, caught within a few miles of the plant, in a whole year.

When we consider the management of wastes at a nuclear power plant we must realize that one of the cost factors in the price of power is the distance over which the power must be transmitted. It is a great advantage to have the consumer near the plant. On the other hand, it has been customary to site nuclear plants away out in the wilds. Recent developments in reactor siting policy in the United States have confirmed this tendency, and this has caused some embarrassment to the people planning for establishment of nuclear power stations. The British, on the other hand, have placed some of their stations quite close to populated areas. In fact in a country as small and densely populated as Britain, it would be difficult to develop a large nuclear power industry without adopting such a policy.

The question we must ask is - are the benefits conferred on the community sufficient to outweigh the risks? To answer the question we must estimate the benefit and also the risks, and express them both in the same units.

We have to face the fact that risks always exist. There is a certain risk associated with getting up in the morning and also with staying in bed. A much greater risk attaches to the decision to drive a car, and a smaller - but still significant - one to deciding to walk instead. It is the job of the waste management department to see that the risks are so small that they are acceptable to the community in relation to the benefits conferred by the use of nuclear energy. We believe that this can be done

even in the present circumstances of public hypersensitivity to radiation hazards.

NPD REACTOR

I have described the site of the NPD reactor as being about twelve miles upstream from Deep River. The population of Deep River includes many people who are at least as sensitive as the general public to radiation hazards, though many of them know a great deal more about the subject than the average man-in-the-street. Any significant contamination of the Ottawa River by radioactive wastes would meet with severe criticism from Deep River. It can be assumed, therefore, that the design of the power station will have taken into account the necessity for careful provision for good waste management. However this applies equally to any reactor design in Canada, because reactors not wholly owned by a Government Agency have to be approved by the Atomic Energy Control Board. The Board has appointed a Reactor Safety Advisory Committee which examines designs in very great detail and follows through with periodical inspections during construction, supervision of approach to criticality, and checks on operating safety. The qualifications and special training of the staff are also examined by the Committee. A similar Safety Committee examines reactor designs for Atomic Energy of Canada Limited.

The site of the NPD power station is convenient in that it has an excellent water supply - necessary for cooling the condensers and for steam generation - and because it is near to the AECL establishment at Chalk River, where expert advice and a multitude of services are readily available. The latter factors are important for this station because, being a small demonstration reactor and the first of its kind in the world, problems might arise which are not routine in the industrial sense. A careful watch on the performance of the installation by people highly competent in the theoretical as well as the practical fields can be expected to yield knowledge that might be missed by operators mainly concerned with the efficient generation of electricity.

However, the site has certain drawbacks from the point of view of waste disposal (Fig. 1). The river is as much as one could hope for, but the land is not. The building is on - in fact most of it is <u>in</u> - solid rock. There is very little over-burden on the rock, and the rock slopes steeply down to the river. Thus facilities for disposal of wastes into the ground are extremely limited. For this reason it is not possible to regard NPD as a "demonstration" of waste management. Apart from river disposal of cooling water and a small amount of drainage from low-level facilities, such as the decontamination centre, all wastes will be trucked to the AECL disposal areas at Chalk River.

Cooling water from heat exchangers will normally not be radioactive, because they are isolated from the river by a secondary system (Fig. 2). The primary coolant - heavy water - passes over the fuel elements inside the reactor and then goes to the boiler, where it heats ordinary water for the generation of steam to drive the turbines. After passing through the turbines, the steam is condensed in a heat exchanger cooled by river water. Thus, for fission products

to get out of the fuel elements and into the river water, there must be a rupture in the sheathing of the fuel, plus a rupture in the primary heat exchanger (the boiler) plus a rupture in the secondary heat exchanger (the condenser).

It must be recognized that one of the primary concerns of a reactor designer or operator is public safety. Without safety he cannot run his equipment, and if there are any hazards to the public, these will usually be greatly exceeded by hazards to workers in the plant. In the case of heavy-water-cooled reactors the necessity for integrity of the system is emphasized by the fact that heavy water costs $28 a pound, and even a small leak in the primary system would impose a heavy cost burden on the plant.

The main bulk of active drainage from the NPD plant will come from the spent fuel storage tank. When the fuel bundles are removed from the reactor they are, of course, very radioactive and contain a large amount of fission products, some of them extremely hazardous. However, the fuel elements are enclosed in a zirconium sheathing. Provided the sheathing is intact, they can be kept indefinitely under water without any activity leaking out. A few of the fuel elements will be ruptured, because nothing in this life is ever perfect, so it can be assumed that the water in the spent fuel tank will be contaminated. It is therefore necessary to equip the tank with a purification system.

At NPD the water in the spent fuel storage tank is pumped through a filter to remove particulate material (mainly dust and algae) and through an ion exchange resin to remove radioactive elements (Fig. 3). The water in the tank is purified before it is put in, because any dissolved ions would reduce the efficiency of the resin column. The water is also passed through a heat exchanger to remove the heat generated by decay of the fission products in the fuel elements.

A small volume of the tank water is continuously bled off and replaced by ion-free water. This drainage goes into the process sewer by way of a "switching monitor". This is a device which measures the level of radioactivity in the water. If the level is above a pre-set value, a valve is automatically turned, switching the effluent stream from the sewer into a holding tank. A pumping system enables the contents of the tank to be repassed at intervals through the monitor. If radioactive decay, or dilution by less active water, reduces the activity below the set point, then the flow is directed to the sewer. Otherwise it is returned to the tank.

Other sources of potential activity such as the decontamination room, the laboratory or drains from radioactive parts of the plant, also drain to the process sewer through the switching monitor. The sewer goes into the very large volume of inactive water from the cooling system, and then to the river. Before it reaches the river a proportional dipping sampler takes frequent samples which are pooled in a large container. Daily samples from this container are analyzed in the laboratory to make sure that the switching monitor

is working at an acceptable level and that there are no undetected leakages into the cooling water.

Experimental work to be carried out during the coming summer will determine the dilution to be expected in the Ottawa River during periods of low flow. This, together with the known volume of the inactive cooling water, will enable us to calculate the point at which to set the switching monitor. At first it will be set at a low level and then, as experience is gained in relating the set point to the results obtained from analysis of the final effluent, the set point will be adjusted to a reasonable working level. It is unlikely that this will be higher than would produce the "maximum permissible concentration for long-lived radionuclides in drinking water" in the effluent as it enters the river. In effect this would mean that little credit was being given for dilution by the river water, but it has been possible for the Chalk River Establishment to live with this restriction and, for public safety and public relations reasons, it is a good one to adopt.

The contents of the holding tank will sometimes fail to pass the switching monitor, even when time has been given for decay. In this event a tank-truck will take the contents to the Chalk River Establishment, where they will be evaporated or otherwise dealt with by the regular waste management system. Solid wastes from NPD will also be dealt with at Chalk River, and for this reason I will give a brief description later on of the facilities available for dispersion and containment of wastes at the AECL plant.

Gaseous wastes will be handled at NPD by filtration and dispersion through a 150 ft. stack. The glass fibre Absolute filters have a 99.95% efficiency for particles 0.3 microns in diameter and they hold back practically everything except gases. Among the fission products are iodines, bromines and the noble gases krypton and xenon. Considerable amounts of argon-41 are also produced in air subjected to a neutron flux. These will all pass through the filters, but careful calculations from meteorological data have shown that, under the least favourable of weather conditions, they will present a negligible hazard both to plant workers and to people living in the immediate neighbourhood.

Several times each year maintenance work will require "purging" the normally unoccupied parts of the building. These will be quite radioactive and the air removed during purging will be more active than that normally sent up the stack. However even this effluent will not be hazardous according to meteorological calculations, and it will be possible to select a time for purging when weather conditions are especially favourable for rapid and efficient dispersal of stack gases into the atmosphere.

CANDU REACTOR

The CANDU reactor will be the first Canadian full-scale nuclear power plant, and it is hoped that this station will demonstrate the economic practicability of the Canadian concept of power reactor design. Fundamentally it is very similar to NPD, but it will be ten times as powerful, more efficient, and will be a self-contained unit

in the sense that it will not depend on Chalk River for services. In contrast with NPD therefore, it will have its own complete waste management system. Although it will be built in a fairly thinly populated region, with no large towns in the immediate vicinity, it will not by any means be as isolated as NPD. Realizing that one day we may want to build a power reactor close to a large city, the policy has been adopted that the designs for the waste management system should be based on the assumption that the plant <u>will</u> be located near to a large city.

When the margin of safety is limited it is advisable to hold wastes before discharge until a sample has been analyzed. The conceptual design for liquid waste management at the CANDU reactor is based on this principle. Two large holding tanks are provided at the downstream end of the system, one of which is in use while the other awaits discharge (Fig. 4). The rate of discharge of the latter tank into the main stream of the inactive cooling water will depend on the result of an analysis of the contents. To cover the possibility of error in the analysis, an alarm monitor is included downstream from the holding tanks, and a connection is provided to a third tank, an emergency tank, into which liquid can be discharged to await treatment.

Upstream from the holding tanks are smaller tanks for receiving different kinds of waste. They may be segregated according to various criteria - content of solids or content of radioactivity, for example. Samples from these receiving tanks are analyzed before the contents are discharged to the holding tanks, thus providing an additional insurance against overloading the discharge system. If it is apparent that the radioactive concentration is too high for discharge the contents of any tank can be passed either to the evaporator or to the ion exchangers. Wastes containing high concentrations of ions are unsuitable for deionization by resin beds, and they must either be evaporated or treated chemically.

PURIFICATION METHODS

Evaporation is an extremely efficient method of decontamination. The distillate may contain as little as one millionth of the concentration of the liquid being distilled. It is, however, expensive. Chemical flocculation methods, such as precipitation with lime and phosphate or with ferric sulphate and caustic soda, are much cheaper but seldom give better than 90% purification. Passage of the effluent through beds of minerals such as vermiculite, or organic material like lignite or sawdust, has also been used. The most promising material we have tried up to now is a zeolite mineral called clinoptilolite, which gives about 99.98% removal of radioactive cesium and strontium.

When the effluent has been purified, either by evaporation or by chemical or physical treatment of some kind, we are left with a radioactive concentrate which must be safely confined. The concentrate from an evaporator can be mixed with cement to form a mortar, but because of the dissolved salts the mortar crumbles

easily and has little resistance to leaching. However it can be enclosed in a high-quality concrete box, which is a safe means of burial. It is difficult to mix the mortar in a pre-formed box because it expands during setting.

Material of this kind can be handled by the "concrete monolith" system developed for the confinement of medium-activity wastes at Chalk River (Fig. 5). The waste solution - in our case containing strong nitric acid and ammonium nitrate - is mixed with cement containing 2% of bentonite. The mixing is done with an electric stirrer in a remotely controlled plant. The drums of mortar are placed on a concrete slab at the bottom of a trench in the disposal area, where they are surrounded with wooden forms. Concrete is then poured into the forms to make a large solid "monolith" with the drums inside. This has proved to be a very successful method - ground water and soil samples taken close to the monoliths have never shown more than traces of radioactivity.

The sludges formed in chemical precipitation processes are difficult to handle. They contain at least 80% of water, which is not easy to remove. After pressure filtration or centrifugation they still contain about 60% water, although a British process consisting of freezing and thawing reduces the water content somewhat more successfully (3). We have no experience with flocculation on a large scale, but it seems likely that the floc could be converted to concrete. Ion exchange resins or mineral exchangers, such as vermiculite or clinoptilolite, can certainly be treated in this way. In the United States and Great Britain sludges are usually buried in pits made in soil with a low permeability to water or are placed in drums and dumped at sea.

Solid wastes are fairly easy to handle, though confinement facilities for high-level wastes are rather expensive. Most of the solid waste coming from a nuclear plant is not really radioactive at all, but since it comes from an "active" area, it is presumed to be "active" unless proved otherwise. It tends to be bulky, consisting of paper, rags, protective clothing, packing material and other combustible substances. It can be greatly reduced in volume by baling and then buried or disposed of at sea. Incineration is also used, but the incinerator must be equipped with filters to prevent emission of radioactive stack gases, and the ash must be safely buried.

Wastes that are too active for baling, or are incombustible, can be stored in sealed concrete lined trenches (Fig. 6) or in holes lined with concrete drain pipe (Fig. 7). The latter are specially suitable for small, highly active objects which would cause a high radiation field to be scattered out of a wide trench while it is in use (Fig. 8). A concrete lined trench or hole can be made from high quality concrete with all joints sealed with galvanized steel strip or with asphalt. The painting of asphalt onto the surface of the concrete makes it practically impermeable to water. Disposal into concrete costs about 65 cents per cubic foot at Chalk River, where trenches and holes of this kind have proved to be most successful (4).

The application of these waste management methods to a nuclear power station does not add greatly to the cost of power. Calculations made for the conceptual design of the CANDU waste management system showed that, for a thirty-year period, the amount of ground used would be less than three acres, and the total cost, including operating charges, would be about $66,000 per annum, or 0.05 mills per kilowatt-hour. This is roughly 1% of the estimated cost of power.

The cost of waste management given in the last paragraph includes storage of the fuel elements for thirty years. In most nuclear power schemes the fuel elements are not stored. They are dissolved in acid and treated for recovery of unused uranium and plutonium, and the recovered fuel is recycled. This is a costly and difficult process, and gives rise to intensely radioactive wastes in strongly acid solution. Up to now such wastes have been stored in tanks and have been a source of extra expense and also some anxiety as to the integrity of the storage tanks.

Any form of fuel processing, followed by storage of the wastes, adds to the cost of power. In reactor systems that use costly enriched uranium for fuel it may always be necessary to recover unused uranium-235. However in the Canadian system, using natural uranium and heavy water moderation - where a high burn-up of uranium can be achieved - it does not seem to be worth while even to recover the plutonium, let alone the uranium. The price of uranium is going down, and it seems likely that recovery of fuel by an elaborate chemical process will become increasingly unattractive. For some time it will be much cheaper to buy new uranium, but if the price of uranium rises sufficiently it will become economic to process fuel, and our stored fuel will then be processed. In the meantime, we shall keep it under water in its zirconium sheaths at a very small storage cost, and be freed from the problem of what to do with the high-level wastes.

At Chalk River we have developed a process for incorporation of high-level wastes into glass. This has given very promising results - we have had active glass blocks buried in a swamp below the water-table for two years, and the amount of active material leached out has been so small that we have had some difficulty in measuring its movement through the soil (5).

CONCLUSION

A good deal of alarm and despondency has been generated by the prospect of enormous amounts of highly dangerous radioactive wastes about to be produced by the nuclear power industry. It has been suggested that this problem may imperil the whole future of the industry, or even the future of mankind.

I have tried to show that the problem is not so intractable as it may seem at first sight. We already know enough about waste management to be sure that we can deal safely with these wastes. Costs, even with our present techniques, are not outrageously high.

The standards of safety are extremely rigorous - in the view of some people unnecessarily so. However, we can live with these standards now, and with further developments in this rapidly advancing field we are confident that the existing methods of waste management can be made better and cheaper. Provided that the present insistence on sound design and strict control continues, the world will be able to use nuclear power without appreciably increasing the hazards faced by the human race.

CAPTIONS

Figure 1 Site of NPD reactor during construction, showing proximity to Ottawa River and rocky terrain.

Figure 2 Diagram of CANDU reactor. NPD is similar but has only one steam generator.

Figure 3 Diagram of cleanup system for NPD spent-fuel storage tank, showing filter, ion exchanger and heat exchanger.

Figure 4 Conceptual design of CANDU liquid-waste management system.

Figure 5 Concrete "monoliths" under construction. Note corner of completed monolith (bottom left) and drums ready for enclosure in concrete. Concrete pads ready to receive more drums in background.

Figure 6 Active waste packed into concrete trench. Note that waste is boxed or wrapped in polyethylene film to protect disposal crews from contamination.

Figure 7 Diagram of "Tile Hole" for small, highly radioactive objects.

Figure 8 Tile Hole in use. Disposal is inside shipping "flask" - a heavily shielded box with a sliding gate at the bottom worked by a crank. When object falls out of flask, momentary radiation causes "kick" on monitoring instrument.

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Figure 1.

Figure 2.

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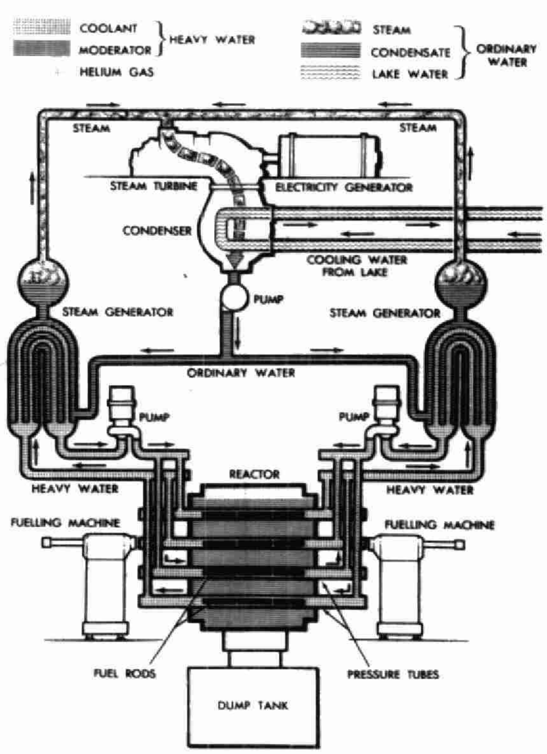

DOUGLAS POINT FLOW DIAGRAM

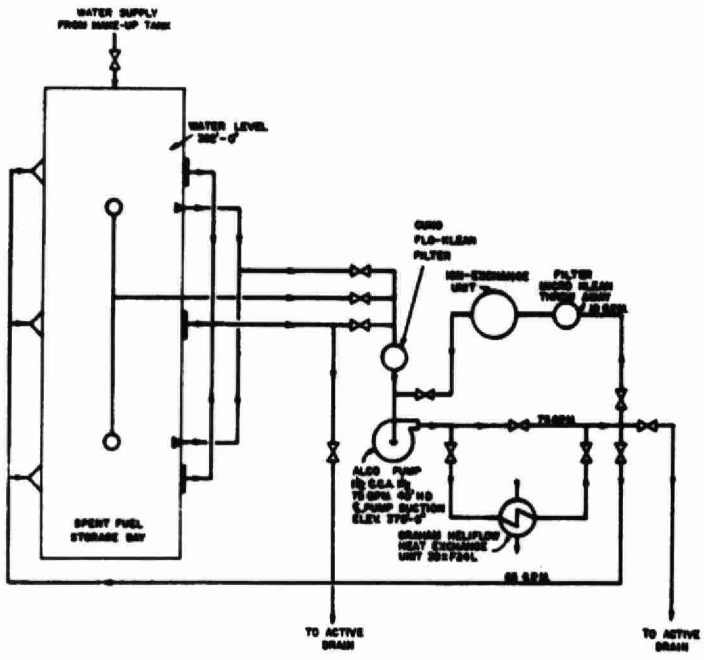

Figure 3.

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CANDU LIQUID WASTE DISPOSAL SYSTEM

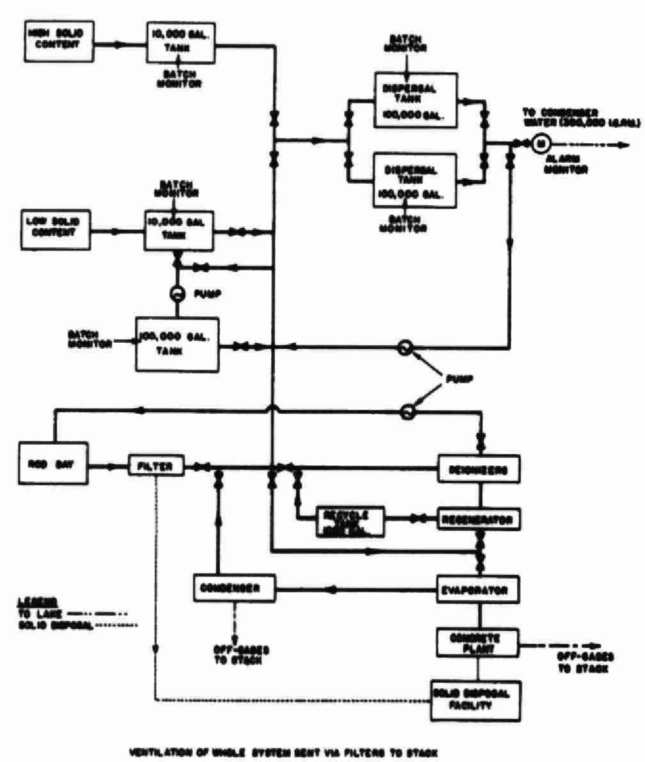

Figure 4.

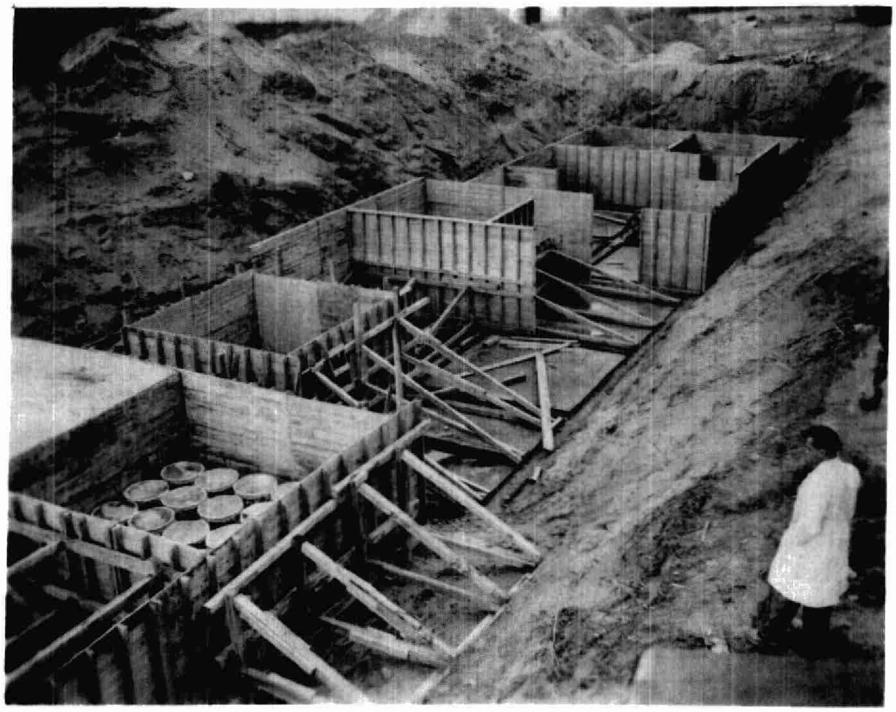

Figure 5.

Figure 6.

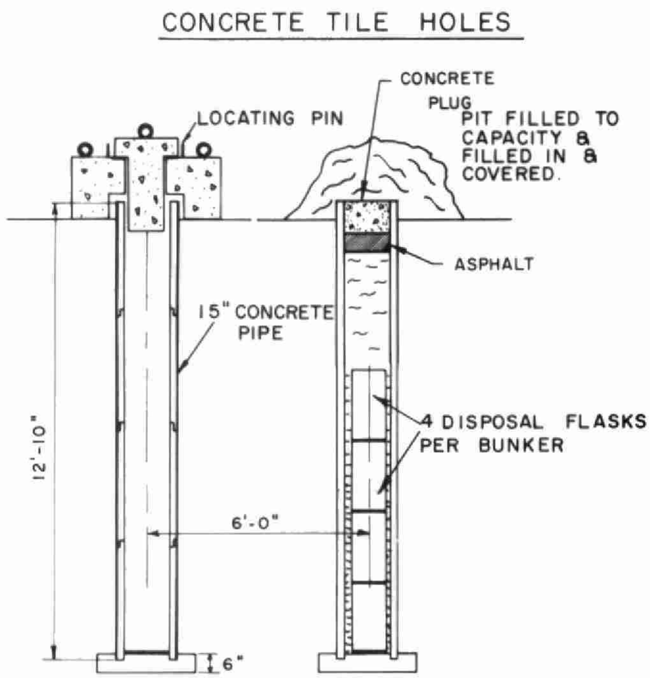

Figure 7.

Figure 8.

DOMESTIC POLLUTION OF FARM DRAINS

by

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INTRODUCTION

At this time it is certain that much benefit is being derived from the study of pollution problems, and the seeking of solutions that should be satisfactory to the public in general. The correction of pollution might be rather hard on the offending parties in many ways, particularly financially. The subject of pollution from industrial wastes seems to have been fairly well covered to date, which of course would include such industries as tanning, petroleum, canning, cheese making and paper making. This paper will be confined to pollution from domestic waste, or in plain words, sanitary sewage.

DEPARTMENT OF PUBLIC WORKS' INTEREST

The Department of Public Works in administering the Provincial Aid to Drainage Act, pays grants in the amount of 33 1/3% of the cost of approved agricultural drainage works in Southern Ontario, and 66 2/3% of these costs in Northern Ontario. It can, therefore, be fairly assumed that the Provincial Government is a party to the construction and maintenance of these drainage works, some of which are a combination of open and covered drains.

THE PROBLEM

Many farm drains of necessity run through small communities, sometimes in pipes, and sometimes in open ditches. It is definitely known that in quite a number of cases, there are illegal connections made from septic tanks and residences to these drains by people who apparently do not understand how they endanger the health of farmers through whose fields the drain subsequently flows as an open ditch. On at least several occasions, cattle and livestock have been poisoned by drinking from streams polluted by domestic wastes. Some farm wells which are located in close proximity to

the ditches have been rendered useless by reason of percolation from these contaminated ditches. Swimming pools are beginning to dot the landscape in suburbs and areas close to villages and towns. Many obtain their water supply from streams nearby, some of which are polluted by domestic wastes.

It has been reported that some market gardeners and farmers, who produce table vegetables, such as lettuce and celery, are irrigating these crops by pumping polluted water from the ditches, even though there is some regulation about not irrigating these crops in this way prior to 10 days of harvesting. Some pollution danger might very well exist even after that length of time. Most of the cases in the past where domestic pollution has occurred to the detriment of farmers down-stream, have been settled out of court by the guilty parties, rather than have them given publicity.

RE-ACTION FROM AUTHORITIES

The writer has investigated the problems with several of the leading drainage engineers of Ontario and has on file a record of quite a number of cases which provide proof that this has been going on for the past number of years. The Medical Profession in general, and the Health units in particular, are reasonably concerned about it. In some cases the resident medical doctor, whether he is on the local Board of Health or not, is the private physician to people who are guilty of illegal drain connections. There is quite a temptation for the Doctor not to be too hard upon the culprit, as any drastic action could effect his private practice.

The Township Boards of Health have often been made aware of suspected sources of pollution. They usually have Inspectors who have the right to investigate and trace down the parties responsible for such pollution. However, this is not an easy matter. It becomes necessary for the Inspector to have private property such as lawns dug up to investigate the drainage system from the seepage beds, and in the event that nothing contrary to regulations is found, the Municipality becomes faced with paying damages to the person whose property has been injuriously effected. You will readily understand that this often proves very expensive and also somewhat embarrassing when nothing wrong is found.

The Ontario Water Resources Commission is taking action with regard to the problem of Municipalities discharging raw sewage into rivers and lakes. The scope of this paper only covers the effect of domestic sewage pollution on open ditches running across farm land.

Municipal Engineers when retained to make reports on farm drainage schemes, generally insist that the awards or reports could not properly deal with the matter of pollution, even though pollution was often the prime reason for the initiation of the drainage works. The reason is that pollution is always both illegal and actionable. In the past, the remedy was a complaint to the Ontario Department of health, or to the Ontario Water Resources Commission.

I would like to quote an article written by R.B. Burn, Esq., a

lawyer of Welland, Ontario, which appeared in the Canadian Engineer, 5th April, 1932, entitled "Legal Aspect of Stream Pollution", in which he cites several decisions:

Under the heading "Examples of Pollution", he says:

"The term 'Pollution', as used in this sense means anything that changes the natural quality of the water. One is entitled to have it flow to him in its natural and undefiled state.

Examples from actual cases are as follows:

(a) Constructing a cesspool near a well that will contaminate it.

(b) Letting off water made noxious by precipitation of minerals, or dye wares, or liquor, or indigo, or potash or acid.

(c) Discharging heated water.

(d) Sewage.

(e) Rendering the water unfit for domestic or culinary purposes.

(f) Rendering it unfit for cattle to drink, or

(g) Rendering it unfit for fish to live in."

TYPICAL CASES

Several typical cases of domestic pollution of open drains have been selected from those on file, to illustrate the serious nature of the problem. The lack of definite action taken in the past to correct domestic pollution may surprise you.

Williamsburg Township (Stormont, Dundas and Glengarry Counties)

Some residents of the Village of Williamsburg had connected septic tanks and sewers directly to a storm water drain running through the village. The solid material settled out in the slower reaches of the drain, crossing farm lands downstream, and gave rise to a very offensive and septic condition. It was so bad that difficulty was experienced in getting a contractor to work on improving the drain. However, it was eventually done, and the excavated material was used as a good cheap fertilizer.

McKillop and Tuckersmith Townships (Huron County)

Property owners in the area affected by Silver Creek in the Townships of McKillop and Tuckersmith, as well as the Town of Seaforth were fully conversant with the legal action in which the Town of Seaforth was involved. In the 1920's the Provincial Health Department forced the Seaforth Creamery to install a tile bed filter system to

abate the nuisance of its milky wastes. However, the most serious pollution problem there, was the effluent from cesspools, poorly constructed septic tanks, etc., passing through the Town's drains and ditches into the creek. There was much talk about the matter, but nobody went so far as to take any legal action.

Mersea Township (Essex)

A farmer had a cow die from drinking polluted water from the Selkirk Drain, which runs through his property, and into which the Town of Leamington drains its sewage further upstream. The Town paid the farmer for the loss of the cow, and also paid the farmer for erecting an electric fence alongside the drain, in order to keep the cattle from having access to the drain, and drinking the water.

Colchester South Township (Essex)

Another similar case having a much different ending was where a farmer had some cows die from poisoning through drinking water from the Richmond Drain, into which the Town of Harrow drains sewage further upstream, and also into which a large canning factory in the Town of Harrow drains its effluent. A complaint was made at the time, and the Ontario Department of Health sent an inspector to visit the site. The day before the inspector arrived, there was a very heavy rain. The result was, when the inspector visited the scene, the heavy flow of water caused by the rainstorm had flushed away most of the contamination that had heretofore existed on the lands of the complainant, and thus the evidence was lost.

There was another instance on the same drain, where a well-to-do owner had constructed a very expensive home on rolling lands adjoining this drain in the Township. He also constructed a dam across the drain, so as to retain a considerable amount of water in it, and constructed a pool adjoining the drain, into which he had placed several species of fish. On one occasion, the water in the municipal drain became so polluted that all his fish were killed.

Tilbury East & Raleigh Townline Road (Kent)

The Ward drain runs along the Westerly side of this road, and drains a considerable amount of farm land, together with drainage from the Police Village of Merlin. In the summer time, when there is very little rainfall, the effluent in the drain downstream from the Village often has the appearance of ink, and the stench is terrible. There is no doubt that this is caused by the pollution in the drain from domestic sewage entering it from the Village.

Mersea Township (Essex)

Here there is a municipal drain flowing through part of the Township, and into which there is considerable drainage from the Town of Leamington upstream. For many years some of the farmers downstream have used water from this drain for irrigation purposes.

The pollution in the drain has become so great during the dry-weather flow period that the farmers using the water for irrigation purposes have been warned not to do so on certain types of vegetables that are used for consumption in the raw state, up to a limited time before such consumption.

ONE SOLUTION OF DOMESTIC WASTE DISPOSAL.

Unless criticism is of a constructive nature, it is very often unwise to offer it. My remarks so far could be taken to be in the destructive category, unless some simple and inexpensive method of domestic sewage treatment was suggested. Some of you, no doubt, read the very interesting article in the Reader's Digest issue of August, 1960, under the caption of "Nature's Wondrous Way with Waste", by Don Romero, Assistant Professor, School of Journalism, University of Missouri. For the benefit of those who missed this "needle in a haystack", I would like to quote portions of the article, and in doing so state that I have had similar experience with simple sewage treatment plants for the Dominion and Provincial Governments.

"Since 1956, government officials from Washington, technicians from virtually every State in the Union, and even visiting scientists from Europe and Latin America have been journeying to the little town of Fayette, Mo.- to take a long and incredulous look at a pond. Fayette's 3100 citizens are justifiably proud of their 15-acre lagoon. It has unfailingly provided them with seemingly miraculous benefits, and it has been officially selected by the U.S. Public Health Service for a five year study.

Day and night for the last four years, all the sewage from the town of Fayette has poured into this three-foot-deep pond. Although no chemical or mechanical means has ever been used to purify the sewage, the pond has remained odorless and clear blue-green in color. The effluent, as shown by daily analysis, achieves a high degree of purification. Frogs and turtles live in the water, and loons and geese come there for refuge.

The secret of the Fayette pond lies in the recent rediscovery of one of nature's oldest wonders - a method of purifying sewage that is simple, safe and inexpensive. 'With our modern technology', says one public-health official, 'we tend to think that we can purify sewage only with costly and complicated mechanical installations. The fact is, nature can do an excellent job on everything except certain kinds of synthetic industrial wastes'.

Nature's agents are worms, snails, bacteria and algae. When sewage enters a 'sewage stabilization lagoon', the solids drop to the bottom, where they are promptly disposed of by worms and snails. The remaining sewage is then attacked by bacteria and one of the most powerful of all purifying agents, oxygen - which algae, under the stimulus of sunshine, produce in surprising quantity.

This natural phenomenon was stumbled upon largely by accident in 1928 when the town of Fessenden, N.D., installed a new sewer

system. Unable to raise additional funds for a mechanical sewage-treatment plant, the town began to pour its sewage into a hastily dug basin at the edge of town. A couple of months later, town officials and State inspectors were astounded to find that the sewage had mysteriously achieved a higher degree of purification than could have been produced by a conventional mechanized plant.

For 20 years, though the pond continued to function successfully, the discovery was dismissed on the ground that "nothing that simple can really do the job". Then in 1948 the town of Maddock, N.D., installed a pond, and within three years another half dozen Dakota towns followed suit.

Not until 1951, however - when Glen J. Hopkins, U.S. Public Health Service regional engineer for seven Midwestern States, made a careful study of the North Dakota ponds - did the pond movement begin to gain national momentum. As a result of his enthusiastic recommendations, the USPHS established the country's first experimental station on the Fayette pond.

Since 1957 the U.S. government, along with its aid for other approved types of municipal sewage plants, has been offering up to 30 per cent of the construction cost of an approved pond, with a maximum grant of $250,000 per pond. As a result, in the three years ending in 1959, 400 municipal ponds were built or scheduled for construction. Another 110 were built by municipalities ineligible for federal aid because of their financial ability to assume full cost. The National Park Service and Bureau of Indian Affairs are now making wide use of such ponds. The U.S. armed forces have built about 30 at installations at home and abroad. In addition, produce houses, poultry dressers, meat packers, laundries and other "sewered" industries are now discovering that sewage ponds can treat industrial wastes just as they do human waste.

Construction consists ordinarily of bulldozing a thick, eight-foot-high dike around a leveled floor. Depending on the value of the land, the USPHS estimates that a pond costs only 25 to 40 percent as much as the cheapest mechanized plant of comparable capacity. The Fayette pond, for example, cost only $60,000, as opposed to the $200,000 which the town would have had to spend for a mechanized plant. As for maintenance, the Fayette pond is handled entirely by one part-time worker. Once a day he inspects the inflow pump, and once a week he oils it; once every three weeks he cuts the grass grown on the dikes to prevent erosion; once a month he pulls out any weeds that may have grown in the pond, to prevent mosquitos from breeding there.

"Our maintenance", says Fayette's mayor, "costs about $350 a year - instead of the $6000 a year we would have to pay to maintain a mechanized plant".

This rock-bottom upkeep is prompting an increasing number of towns to build sewage ponds, the cost of which can be speedily

amortized by the enormous saving in maintenance. The result; an early drop in per capita sewage tax.

Most public-health officials agree that sewage ponds are ideal for small-town use (provided the town has a competent sewer system). There is, of course, a limit on the size of a community which can effectively employ a pond. But the pond at Grand Forks, N.D., for example, will service 40,000 people. And four ponds in Aukland, New Zealand, can service a total of 381,000. The ponds work even where they may be covered with ice and snow for six months of the year; the purification is carried on by anaerobic bacteria rather than by aerobic bacteria and oxygen. There are some 250 ponds in such frigid areas as Montana, Saskatchewan, Manitoba and British Columbia.

Until recently State health departments specified one acre of pond for each 100 people. Now they have raised their limits - up to 200 people per acre in northern areas, 400 in southern areas. "We still don't know what the safe loadings are for these ponds", says Jack Smith, Executive Secretary of Missouri's Water Pollution Board, "but chances are they are considerably higher than the limits now set".

The only serious public controversy that has arisen concerns odor. Opponents of the method insist that the ponds smell. When the Fayette pond was built, four years ago, a USPHS technician was put on 24-hour call; the townspeople were told to summon him if they ever detected the slightest odor. He has never been summoned.

Actually a pond will give off odor only under unusual circumstances. A quick spring thaw may cause the ice on a pond to release gases which have accumulated during the winter. Or a pond may be incorrectly constructed or badly located. A pond should be from three to seven feet deep, circular or rectangular in shape, and constructed in an area where the earth has a normal amount of clay in it to prevent excessive seepage. And it must be situated where it will get both sunshine and wind: sunshine to produce oxygen, wind to keep the water circulating so that the oxygen will be dispersed throughout the pond.

In deference to the fears people have about sewage ponds, most states recommend that they be located at least a quarter of a mile from the nearest dwelling. Yet USPHS biologist Dr. Joseph Neel reports numerous instances in which ponds have been built within 100 yards of a home, church, school, office building, factory or drive-in theater, with no problem of either odor or pollution.

Sanitation authorities agree that the pond method is likely to play an increasingly important role in sewage disposal. Says Glen Hopkins, the USPHS engineer who made the original study in North Dakota: "These ponds are making adequate sewage treatment possible in countless areas which heretofore have been unable to afford this basic public-health facility. They are also helping to solve one of our most critical national problems - the conservation of billions of gallons of water which previously were

being polluted by human or industrial waste".

CONCLUSION

To sum up, the fact remains that serious pollution of open drains crossing farm lands does exist, caused by domestic as well as industrial wastes. Something more than at present should be done to prevent it. The proper authority should exercise very strict control over the matter, and should take the necessary steps to ensure that pollution from domestic wastes is eliminated.

TREATMENT AND UTILIZATION OF DISTILLERY WASTES.

by

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The Food and Drugs Act requires that all types of Whisky, as well as Gin and Vodka, be distilled from grain spirit only and all Canadian distilleries are therefore similar in respect of raw material and basic process.

A modern grain distillery requires more water than any other raw material, and water consumption as high as 600 Imp. Gals. per bushel of grain used, is not unusual. Considering that some Canadian distilleries consume 8,000 bushels of grain per day, and more, it is therefore obvious that an absolutely reliable supply of water is a prime consideration when deciding upon the site of a distillery.

On the other hand, practically all of this water will eventually find it's way back into the natural drainage system of the distillery site. Potentially serious water pollution problems are therefore encountered unless very careful control is exerted over all the effluents leaving the plant.

The process of producing spirits from grain can be outlined as follows -

RECEIPT, CLEANING and STORAGE OF GRAIN:

The more important grains used are corn, rye and barley malt, and most distilleries carry at least a few weeks' supply of grain on hand. As the final quality of their product is, to a large extent, determined by the purity of the raw material, much care is taken to clean the grain on receipt. This is usually effected by a combined screening and air cleaning operation to remove, on the one hand, coarse impurities such as fragments of corn cobs, stalks, etc., and, on the other hand, dust and other fines. The impurities which are so removed from the grain therefore constitute the first waste product which must be taken care of in distillery operations.

MILLING:

The various types of grain are ground to accurately defined standards of fineness, standards which are not only determined by considerations of optimum recovery and quality of spirits, but which are also influenced by the requirements of the by-products recovery plant. For reasons both of economy and good housekeeping, losses in the Mill must be kept to a minimum. Yet, here too, a certain amount of dust is usually produced, which represents a waste product.

MASHING:

The corn and/or rye meal is now cooked under pressure to bring it's content of starch into solution; then the pressure is released and the mash is cooled down quickly to approximately 150°F. A slurry of ground barley malt is now added, which converts the dissolved starch into fermentable sugars by enzymatic action.

For continued efficiency, the mashing process relies on clean equipment, and it is therefore necessary to wash each cooking vessel and the agitators regularly after each mashing cycle. Considerable quantities of water are used here, and appear as a potential waste. In addition, both during the period when the pressure on the cookers is released for "blowing down", and immediately afterwards, when a powerful vacuum pump is used to further cool the mash to the conversion temperature of 150°F, violent ebullition occurs. This can result in noticeable carry-over of droplets of mash into the exhaust line and thus eventually into the sewage system.

COOLING:

After conversion, the mash is cooled down to fermenting temperature of approximately 70°F by a counter-current of cold water in large heat exchangers. The slightly heated, but otherwise uncontaminated cooling water is usually discharged to the sewer. These heat exchangers also require regular, thorough cleaning with copious quantities of wash water.

FERMENTATION:

The cool mash finally reaches the fermenters, usually large tanks of up to 50,000 gallons capacity, and more. Here the mash is adjusted to the correct dilution by the addition of water and/or back stillage which has been recycled from a previous distillation. A quantity of pure yeast culture is now added, and during the next three to five days fermentation converts the sugars into alcohol and carbon dioxide.

The carbon dioxide constitutes one of the by-products of the distilling industry, and in some plants it is recovered for the production of dry ice. Unfortunately, the market for this commodity is insufficient to absorb the entire potential production, and most distilleries therefore simply vent the CO_2 gas to the atmosphere.

As fermentation is an exothermic process, considerable quantities of heat have to be dispersed, and this is usually effected by a system of water coolers inside or outside the fermenters. This cooling effect is particularly important as it is the means by which the rate of fermentation can best be controlled. Considerable quantities of cooling water are usually discharged to waste at a slightly increased temperature, but without any noticeable contamination.

Sanitation is particularly important in the Fermenting Room because foreign or "wild" strains of yeast, or bacteria, can completely change, and actually ruin an entire fermenter of "beer" by the production of various volatile impurities. This type of infection can only be prevented by regular cleaning and sterilization of all Fermenting Room equipment between batches. Again, therefore, large volumes of wash water with, or without the addition of cleaning agents, are involved and have to be disposed of eventually. When no detergents or chemical disinfectants are used, sterilization is achieved by heating the tanks to 212°F with direct steam, which creates further condensate which has to be disposed of.

DISTILLATION:

After fermentation, the beer is pumped to the stills where alcohol and other volatile constituents are recovered, leaving a de-alcoholized beer called "stillage" which is piped to the By-Products Division at approximately 32 to 36 Imp. Gals. per bushel of grain mashed.

The distillates are separated into potable spirit, "heads" and fusel oil. The heads fraction constitutes a very impure grade of spirits, with considerable content of aldehydes and low boiling esters. This fraction is normally used for industrial alcohol and is never discharged to waste. The fusel oil is a mixture of high-boiling alcohols, sparingly soluble in water, such as butyl, isobutyl and the various amyl alcohols. This mixture constitutes a valuable raw material for lacquers and other chemical products, and is never discharged to waste.

The only effluent leaving a distillery to the drains is therefore the considerable quantity of cooling water required in the condensing system. A modern spirits still usually has three or more fractionation or rectification columns and all of these rely for their efficiency on a high amount of reflux from a series of condensers and dephlegmators. Reflux ratios between 6:1 and 10:1 are usually required in all the columns and only a part of the cooling effect required can be derived from a pre-heater for the beer; the balance being provided by cooling water. This water leaves the condensers at temperatures varying between 80 and 170°F. In order to conserve steam this hot water is used for such purposes as boiler feed, mashing, etc., but the major fraction thereof is still discharged to waste.

BY-PRODUCTS RECOVERY:

The "stillage" as it leaves the stills usually contains some 5 to 6% of total solids; approximately one-half of which are in

suspension and the balance in true solution. These solids contain all the protein, fat, fibre, vitamins and mineral content of the grain from which actually only the starch and other soluble carbohydrates have been removed.

As starch constitutes approximately 65% of the weight of the grain, the fermenting process therefore leaves a residue in which the other valuable food materials originally present in the grain have been concentrated three times. This residue has been further enriched by the action of yeast which, it has been shown, increases the vitamin content of the grain during fermentation.

The value of Dried Distillers' Grains as a feed supplement has been demonstrated for a variety of livestock. Probably the best example was given by a demonstration on steers:

One lot of steers was fed corn with roughage, while the other group was fed corn with roughage and additional Dried Distillers' Grains. For each 100 bushels of corn and roughage the first group gained 476 pounds. For each 80 bushels of corn, and the Dried Grains only from 20 further bushels which had been processed at the distillery, the second lot of steers gained 537 pounds.

Similarly, good results have been reported by researchers working on dairy cattle, pigs and poultry.

The value of "stillage" has been appreciated since the earliest days of the distilling industry, and efforts have always been made to utilize it. Originally it was fed directly to cattle together with hay, one steer being required per bushel of grain ground per day. To-day this method has been abandoned by large distilleries in Canada and the U.S.A., although some of the smaller units and most European distilleries still dispose of their stillage to farming communities.

Modern distilleries are today marketing their by-products as a dry material suitable for blending into animal rations. The following 5-stage process is involved in it's production:-

1. Coarse suspended solids are separated by passing the stillage over one or more screens.

2. Many distilleries separate a further quantity of fine suspended material by centrifuging.

3. The coarse solids are pressed to semi-dryness and the liquor so expressed is recycled to Step No.1.

4. The screened and/or centrifuged stillage is concentrated to the consistency of a semi-solid syrup of approximately 1/10 or 1/12 of the original volume in multiple effect vacuum evaporators. The water evaporated from the stillage is discharged to waste, mixed with a large quantity of cooling water in a barometric condenser.

5. The syrup, plus the centrifuge sludge, is fed back into

the coarse solids leaving the presses and after thorough mixing is finally dried in a rotary dryer to approximately 10% moisture. The product of this process is called "Dark Distillers Grains with Solubles" and it commands a regular demand from mixed feed producers.

The composition of this material varies, depending upon the ratio in which various grains were used. Normal limits are as follows -

Protein	23 to 29%
Fat	6 to 10%
Crude Fibre	5 to 10%

As an alternative procedure, some distilleries dry the solids only as they leave the screens and presses, and do not add syrup. The resultant product is called "Light Distillers' Grains"

Protein	23 to 29%
Fat	6 to 10%
Fibre	8 to 15%

A third type of feed produced by distilleries is obtained by film-drying the evaporated syrup only. The resultant product is marketed as "Distillers' Solubles" containing,

Protein	23 to 29%
Fat	6 to 10%
Fibre	3 to 5%

It has been established that a pH value of 4.0 to 5.0 during fermentation is required in order to produce good quality alcohol at a high rate of recovery. This slight acidity is usually obtained by "souring", which is a preliminary lactic acid fermentation of the yeast mash. As a result, a certain amount of lactic acid, as well as other volatile organic acids, occurs in the stillage. These acids create serious corrosion problems in the by-products recovery plant and the modern tendency is therefore to replace copper with stainless steel as a material of construction for presses, screens and evaporators.

The greater part of the potential pollution load of a modern grain distillery is thus eliminated by feed recovery, and in spite of the very considerable fuel and labour costs involved, the products of this process are valuable enough that the by-products plant can usually show a slight profit.

TREATMENT OF OTHER LIQUID WASTES:

While the recovery of feed from stillage can therefore constitute a profitable operation paying for it's own costs, there are considerable quantities of other wastes in a distillery, most of which are far more dilute and all of which represent considerable disposal problems. Dealing with them is not nearly as profitable as stillage recovery, and is only undertaken in order to avoid water pollution.

1. Wastes from cooking:
   The wash water from the cookers contains far too little solids to be used profitably for by-products recovery. At Corby's special pipelines were laid to transfer it to the fermenters where it replaces part of the diluting water that is normally required.

   Blowdown:

   If the blowdown rate is too fast, some dissolved and suspended solids are present in the droplets carried over into the exhaust lines when the pressure is released on the cookers. Although the gallonage involved is invariably very small, this waste has a very high B.O.D. and special equipment was therefore installed at Corby's to collect it and transfer it also to the by-products plant, and thus keep it out of the sewers.

2. Coolers:

   Special trays have been installed at Corby's to collect washings and spillage for transfer to the by-products division.

3. Yeast Plant:

   All wash water from this department is channelled either to the stills or else to the by-products division.

4. Fermenters:

   Considerable quantities of wash water from the fermenters, as well as the condensate forming when they are sterilized with direct steam, are usually drained to the beer feed pump and thence to the still. This water therefore eventually ends up in the by-products division, where the solids are recovered.

5. By-Products Division:

   Here, too, good housekeeping practices necessitate thorough washing of tanks, equipment, pumps and pipelines. All the water so used is, however, collected in the by-products tanks and eventually recovered with the stillage.

The entire question of by-products recovery and pollution control is often a decisive factor in determining the output of a distillery. The potential production of the entire plant is quite flexible, and there is usually some reserve capacity for milling, cooking and fermentation, while modern stills also can operate efficiently over quite a large range of flow rates.

A by-product recovery plant, however, is run most economically at full capacity, and in view of the very considerable capital investment involved,

both for the equipment itself and the steam requirements, this department is usually designed rather closely to the normal capacity of the distillery.

In the case of Corby's, the feed recovery plant has been a deciding factor in determining the weekly production. While some 20,000 bushels per week could easily be processed by all other departments, the lower capacity of the by-products division has set the actual throughput at 17,000 bushels, in order to ensure complete recovery of stillage.

FINAL EFFLUENTS

The effluents that are being discharged to waste in a modern grain distillery therefore include the following -

The milling, mashing and yeast departments discharge only practically clear washing water to the drain. This also applies to all other departments handling the alcohol after distillation, such as maturing warehouses, blending and bottling departments.

From the mash coolers, the fermenting room and the distillery, large quantities of warm but uncontaminated water are discharged to waste. The fact that most distilleries are situated on large bodies of water, tends to reduce, by dilution, the deleterious effect of this heat on aquatic life.

Finally, the major flow of effluent is derived from the by-products division, and specifically from the barometric condenser which discharges a mixture of condensate and cooling water. This condensate contains a small amount of organic matter derived from organic acids and wax-like substances which are steam-distilled from the stillage in the vacuum evaporator. The BOD value of the mixture is usually considered to be sufficiently low to be directly discharged to waste.

Distilleries such as Corby's operating in rural areas are faced with the additional necessity of providing disposal facilities for domestic sewage.

CONCLUSION

The distilling industry succeeds in recovering the major part of it's potential wastes in the form of marketable feedstuffs.

SPRAYING SODIUM WASTES ON SOILS

by

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Sodium salts are used by many industries somewhere in their processing or manufacturing program - in a canning process as caustic soda or in tanneries as the chloride or as the hydroxide, Sodium occurs naturally in most Ontario soils but in minute quantities. In certain arid areas of Canada and in the world, the concentration of sodium is great enough to prohibit the growth of commercial crops. Water that permeates saline rocks may be too salty for crop irrigation or too salty to leach out accumulated salts in the soil.

As water percolates the soil, it carries with it a host of impurities that man has put in it. Soil scientists are particularly interested in the chemicals, the organic compounds, and the microbiological components that may be classed as wastes. In the Department of Soil Science, Ontario Agricultural College, a research project has been directed towards the study of the adsorbtion and retention of the cation sodium from percolating solutions.

CATION EXCHANGE CAPACITY

The physical and chemical mechanisms by which sodium is retained in the soil are well known and documented in the literature. The exchange capacity in soils, similar in importance to photosynthesis in plants, is confined to the colloidal fraction - particles that are less than two microns in diameter. These small particles are mineral or organic in nature and are uniquely characterized by a net electrical charge that is negative in sign. The negativity of the colloid is satisfied by adsorbing positively charged ions, e.g. sodium, potassium, ammonium, calcium, magnesium, hydrogen, and others.

In a general way, the suite of adsorbed ions in most Ontario soils is dominated by calcium, magnesium, and potassium; in some

soils, hydrogen occupies a large percentage of the exchange complex to give an acid soil. This condition is remedied by adding a calcium ion usually in the form of calcium carbonate, because the carbonate is relatively cheap. Several months are required for enough calcium to become soluble and replace the hydrogen on the exchange.

SALINE SOILS

The major cations making up the soluble salts in saline soils are sodium, calcium and magnesium; the anions include sulphate, chloride, and bicarbonates. The build-up of sodium salts occurs because calcium, magnesium, and potassium tend to form salts of lower solubility.

At present, we are concerned with saline soils per se, in that they could be developed under some existing disposal spray programs in Ontario. Chemically, these soils are characterized by:

1. conductivity of the saturation extract greater than 4 mmhos;

2. saturation of the exchange complex with sodium to be less than 15 percent;

3. pH less than 8.5.

When the salts are removed by leaching to the point where the conductivity of the extract is less than 4 mmhos, the soils are said to be normal.

Under certain conditions, the exchangeable sodium may exceed 15 percent and the conductivity of the extract become less than 4 mmhos. In the absence of excess salts, the exchangeable sodium will hydrolyze to form sodium hydroxide and react with carbon dioxide to form sodium carbonate and sodium bicarbonate. These compounds tend to disperse the organic matter making it free to move with the water in the soil. Thus, we have a soil that appears to have a deeper surface layer, but actually the dispersed organic matter occurs as a coating, not as a separate entity, on a soil aggregate.

RECLAMATION

The reclamation of a sodium soil is essentially an exchange of sodium for calcium from a soluble calcium salt. The exchange may be hastened by applying calcium sulphate in the form of gypsum. Applications of sulphur are made as a means of replacing the exchangeable sodium. The sulphuric acid derived from the oxidation of the sulphur, brings about a hydrogen-for-sodium exchange. If the soil contains calcium carbonate, the sulphuric acid reacts with it to produce calcium sulphate, which can then bring about a calcium-for-sodium exchange. Calcium carbonate or lime is an ineffective source of calcium in soil having a high pH because of its low solubility under such conditions.

The reclamation process is easier to carry out in coarse-

textured soils than in clay soils for two reasons;

(1) lower cation exchange capacity and
(2) greater permeability to water.

Fine-textured soils, that are essentially impermeable to water, are non-reclaimable under present economic conditions.

An Example in Ontario

Physical and chemical determinations have been made on a soil that is being used for the disposal of sodium hydroxide. Some of the important physical and chemical characteristics of this soil are given in Table I.

TABLE 1 - Selected chemical and physical properties of Chinguacousy clay.

Depth (in.)	Clay $\angle$0.002 mm. Per Cent	Sand 2.0 - 0.05 Per Cent	Organic Matter Per Cent	pH	Permeability
0 - 6	54	21	7.0	5.6	slow
6 - 12	54	21	3.8	6.2	slow
12 - 24	60	14	$\angle$1.0	6.4	very slow
24+	64	12	$\angle$1.0	7.1	very slow

In the first year of operation it was estimated that the soil received the equivalent of 1500 lb. of sodium hydroxide per acre during August to November. The laboratory determinations were made the following July or nearly one year later. The sodium applied would be equivalent to 1.9 m.e. The chemical analysis indicated that 0.97 m.e. or 50% of the applied sodium had been retained on the exchange complex of the surface 12 inches of soil, Table 2. The conductivity of the saturation extract had increased from 0.12 to 0.20 mmhos. The 1960 samples were taken during September when the disposal program was in operation. The adsorbed sodium was slightly less than the preceding year, but the conductivity of the saturation extract had increased 6 times, (0.20 to 0.72 mmhos). This would indicate that the sodium was still in solution and could be eventually adsorbed by the clay particles or permeate slowly into the subsoil. This hypothesis could be checked by sampling just prior to the commencement of spraying operations and after the winter rains and snows had leached the sodium from the soil pores.

TABLE 2 - The exchangeable cations, pH, and conductivity of the surface 12 inches of a soil used for the disposal of sodium hydroxide. (Chinguacousy clay, C.E.C. 24.0 m.e./100 gm)

Cation	1958 Untreated	1959 After 1 Year of Use	1960 During Operations
Na	0.19	0.97	0.90
K	0.40	0.36	0.40
Ca	15.4	14.7	15.0
Mg	4.1	4.4	-
pH	5.6	6.1	6.2
Conductivity (mmhos/cm)	0.12	0.20	0.72

1958 .... prior to any application of NaOH

1959 .... one year after receiving 1500 lb./ac. NaOH

1960 .... sampled during spray operations.

LABORATORY STUDIES

The data from the field project indicated that the adsorbed sodium had increased from 0.2 to 0.90 m.e. but did not show the cations that had been released, Table 2. Under laboratory conditions it would be possible to eliminate some of the unknown quantities that exist under field conditions, by using a solution of known concentration and a uniform mass of soil.

Bhuiya (1) constructed columns of soil with each 1-cm. layer separated by a fibreglass screen. This procedure permitted him to measure in detail the adsorbed sodium as a function of soil depth and to determine the ion or ions that were involved in the exchange. The leaching solution contained 216 m.e. per litre - enough sodium to occupy three times the available exchange sites on the soil. Under these conditions, he was able to demonstrate the "column effect" referred to in the literature. The effect is described as the distribution of adsorbed sodium ions as a function of depth, Fig.1. There appeared to be a threshold value or an initial quantity of sodium required before calcium was replaced from the exchange sites. The m.e. included in the threshold value were probably due to the exchange of readily released ions, potassium, ammonium, and perhaps hydrogen. When calcium retained was plotted against sodium adsorbed for all depths a straight line resulted, Figure 1.

Bhuiya concluded that under non-equilibrium conditions the ratio of the quantity of sodium adsorbed and calcium replaced was not the

same at all depths. More sodium was adsorbed by the uppermost layers. To demonstrate the reclamation of the sodium soil, he found that with dilute solutions or calcium chloride the exchange was essentially chemically equivalent.

CROP TOLERANCES

There has been considerable interest in the possibility of using brackish or saline water for irrigation in some of the Eastern Seaboard States (2). Research was conducted for the purpose of determining the effects of various salt concentrations on the growth of plants and on the exchangeable cations. Green beans, which are quite tolerant to sodium in solution, were watered with solutions of sea water containing 473 m.e. per litre of sodium chloride or more than double the concentration of sodium used by Bhuiya.

Relative yield data, Figures 2 and 3, indicate little effect of salinity at low values, but at conductivity values above 4 mmhos in the saturation extract, there is a linear decrease in yield with increasing conductivity values. It would appear that under saline conditions the equilibrium in the soil solution was the determining factor in the uptake of ions by the bean plants. The exchange capacity and the percent base saturation of a soil effect the composition of the equilibrium solution.

RESEARCH PROBLEMS

Research has established important facts applicable to the disposal of wastes on soils by irrigation; there are physical and chemical limitations to the adsorbing capacity of any soil; the preferential adsorption of cations is determined by the valence of the ion; the quantity adsorbed is controlled by the exchange capacity; soils retain minimum quantities of anions.

Research is required to develop an alternative method for the disposal of wastes from canneries virtually surrounded by impermeable soils. At the present time we do not have a method that is economically feasible for the reclamation of impermeable saline soils. Consequently, the research staff must follow the build-up of undesirable wastes in a soil and institute an alternative plan for disposal before the soil is beyond reclamation.

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SESSION NUMBER THREE

W. G. DAVIS, M.P.P., Peel,
Session Chairman.

DISPOSAL OF SPENT CAUSTIC AND PHENOLIC WATER IN DEEP WELLS

by

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SUMMARY

The major factors to be considered in the problems of waste disposal in deep wells are discussed. The disposal problem in Sarnia Refinery is described, and the disposal well project is outlined. Some geological information specific to the Sarnia and east Michigan areas is presented.

The techniques of disposal well stimulation are briefly discussed and the appendix contains sketches showing the location of the wells in the Refinery, and a geological structure diagram for the disposal formation.

INTRODUCTION

The disposal of troublesome industrial wastes into underground formations has attracted the attention of the operators of many manufacturing and chemical industries as a simple, low cost disposal procedure. A review of the experience of brine disposal facilities, oil field water flooding operations, and those relatively few industrial waste water deep well disposal projects show that careful study and analysis of this procedure is necessary before this method of disposal is adopted in any particular situation.

The selection of a successful industrial waste disposal procedure is always subject to the specific characteristics of the waste. In deep well disposal additional factors exist which must be considered before the decision is made to use this method of disposal. It is the intent of this paper to outline the more important features to be considered when a deep well disposal system is proposed.

MAJOR FACTORS IN DISPOSAL WELL PROJECTS

(1) The Attitude of Regulatory Bodies. In Ontario the regulatory bodies are the Ontario Water Resources Commission and the Fuel Board of Ontario. The Ontario Water Resources Commission have naturally a great interest in sub-surface water disposal. Because of the uncertainties of much of what goes on underground, and the long-term implications of contaminating surface water supplies, the Ontario Water Resources Commission and Fuel Board must be consulted before any deep well disposal project is started.

Only after the requirements of these bodies are met, and all responsible steps to avoid pollution of sub-surface potable water are taken, will permission be granted to go ahead with a disposal well project.

(2) Assured Success of the Venture. Every reasonable effort should be made to provide the necessary equipment and treatment to assure compatibility of the waste with both the receiving formation and with the receiving reservoir brine. Many compatibility tests have been made by persons who are quite willing to assume that mixing and storing of two solutions of waste and brine at ambient temperatures and pressures constitute a true test of compatibility, when in reality the actual physical conditions in the formation are far different than those conditions existing on the laboratory bench. Interpretation of the results is often equally unrealistic, such comments as "slight cloudiness after two weeks" being accepted as proof that compatibility exists.

The disposal of oil field brines has a considerable experience record to show that similar brines, returned to the same formation, can become incompatible and precipitate-forming because of the release of carbon dioxide held under pressure in the formation and subsequently released when delivered to the surface at atmospheric pressure.

Bacteria, iron, sulphur, heavy metal hydroxides, dirt and dust and alkaline earth salts such as sulphates and fluorides can all contribute to well failure unless removed. The prediction of the chemical equilibria in a multi-component brine existing within the formation at high pressures and at temperatures of approximately 70°F-170°F is a complex undertaking, but the problem may be qualitatively solved by pretreatment to remove some of these offending materials if necessary. The physical and chemical composition of the formation itself may make the removal of certain of these materials unnecessary. The following general rules may be of some help:

1. The waste should be completely freed from suspended matter, dirt, etc.

2. The waste should have a pH below the pH of the receiving formation brine of at least one-half pH unit. In other words the waste should be slightly acidic to the formation.

3. The waste should be relatively free from dissolved or entrained air or oxygen. Deaeration will reduce corrosion and bacterial growth.

4. The waste should be free from hydrogen sulphide and sulphur dioxide and should be neither oxidizing nor strongly reducing. It should be free from heavy metal ions such as hexavalent chromic, ferrous, ferric, cupric, barium, stronium, aluminum, manganous or other ions capable of forming precipitates by reduction, neutralization or metathesis.

5. The waste should be sterile, free from bacteria, algae, or fungi. A chloride residual should be maintained where the chemical oxygen demand will permit. This may be impractical in reducing process or refinery wastes. The waste may be injected hot if necessary to maintain sterility or to obviate the need for cooling.

6. The waste should be free from organic materials which might polymerize, decompose, precipitate, or become viscous, including hydrocarbons, resins, and other organic materials.

(3) <u>The Protection of Potable Water Supplies</u>. The legal implications of contamination of fresh water aquifiers are so involved and serious that every precaution that can be taken to eliminate such a possibility should be considered as good insurance.

It is relatively easy to monitor leakage around the well itself. Unfortunately it is not so easy to monitor contamination at some distance from the well if such a requirement is thought necessary. If an impermeable cap rock exists over the disposal strata and the absence of wells piercing the cap rock is certain, then the probability of contamination of potable water supplies above this cap rock is quite small. If such a condition does not occur, then the fortuitous occurance of water wells adjacent to the disposal area or the deliberate installation of such wells into the lower depths of the fresh water formations may provide test points to determine the start of contamination. Reasonable assurance may be had that no contamination of underground aquifers has occurred if these test wells remain uncontaminated.

The possible contamination of potable water and surface water supplies is by far the greatest problem in getting approval for a disposal well project.

It should be kept in mind that the most complete precautions can not prevent some legal action by those who may believe themselves injured by disposal well operations, but such precautions can greatly assist the operator in disproving such allegations.

(4) <u>Environment of the Disposal Formation</u>. Obviously, a necessary condition of any deep well disposal system is the existence

of a suitable strata into which the water or contaminated material may be injected.

Many types of disposal formations can be considered. Since the disposal zone should be always completely isolated from any fresh water-bearing strata, it will normally contain natural gases or brines under some considerable pressure and at some elevated temperature. The porosity and chemical composition of the formation must be known to evaluate the compatibility conditions.

In some areas this information may be available in the records of exploration companies. In areas in which exploration for oil has not been carried out this information is probably lacking or fragmentary at best, and about the only way to obtain it is by drilling a test hole and coring it.

When the formation is basically limestone, the natural brines existing in the formation will be in chemical equilibrium with the solid phase limestone constituents at the existing temperature and pressure. The brine will be present at an equilibrium pH value, dependent on the temperature and pressure, which will be maintained whether or not waste liquids are introduced. If this equilibrium pH is changed, the various solid concentrations will be adjusted to the equilibrium composition by dissolving the formation or by precipitating from the solution until the equilibrium is again attained. Excessive dissolving of the formation, if deliberate, is expensive in acid requirement; insufficient acidification will result in deposition and plugging to an extent determined by the formation structure. Ideally the objective would be to determine what pH at the surface would give a pH at reservoir conditions that would be very slightly dissolving and add just sufficient acid to maintain this condition. Little can be generalized about formation brine. The degree of mineralization varies widely from relatively low total solids to concentrations approaching saturation of the principle constituents.

(5) Chemical Compatibility. Incompatibility exists between formation brines and injected wastes when a chemical reaction between the two products produces a precipitate or deposit, or releases a gas. These reactions may require considerable time for completion but they take place under the temperature and pressure of the formation, and in the presence of all three phases of the formation. The reactions which can cause plugging precipitates to form may be classed as follows:

(a) Alkaline Earth Precipitates; Precipitates from alkaline earth metal salts, such as carbonates, bi-carbonates, hydroxides, fluorides, ortho-phosphates, and sulphates. Excessive silica may be arbitrarily included in this group.

(b) Heavy Metal Precipitates; Precipitates from the heavy metals, usually iron, chromium, aluminum, cadmium, zinc, manganese or others, yielding insoluble carbonates, bi-carbonates, ortho-phosphates and sulphides.

(c) Oxidation - Recuction Precipitates; Precipitates resulting

from oxidation - reduction reactions, such as the reduction of chromate ion by hydrogen sulphide to yield sulphur. These compounds are usually peculiar to industrial wastes.

(d) Organic Polymers. These are formed from polymerization reactions involving organic wastes or resins which might polymerize to form insoluble matter under the conditions in the reservoir.

(e) Suspended Solids. Dirt, solids, dust, or any material of this nature carried into the well by the waste flow may plug off the pores in the disposal formation.

(f) Bacteria and Algae Growths. These materials are deposited in the strata by the waste and grow under reservoir conditions or, if dead, may be filtered out on the formation and act to plug the face of the well.

(6) Corrosion. Corrosion may be a serious problem in the piping systems handling the water to be injected. Corrosion of surface piping is of no great consideration since it is simple to replace; but corrosion of piping in the well is a different matter. It may be worthwhile to use corrosion resistant material, or construct the well in such a way that the injection casing can be removed and replaced if necessary.

(7) Injection Pressure. It is common procedure in oil field water flooding operations to inject the water by high pressure pumps. The objective of the water injection is to drive oil through the strata by high pressure water. The use of high pressure injection in industrial waste disposal has certain disadvantages which should be carefully considered before the pumps are installed. The regulatory agency may prohibit pressure injection on the ground that the danger of contamination of fresh water strata is increased, particularly after the well has been operated for some considerable period of time and the casing in the well may be corroded. A regulatory agency may also regard high pressure injection as evidence of well failure. Ideally, a disposal well should receive waste at a well head vacuum and not require injection pressure.

Generally, it is much more economical to drill one, two or more wells, and pump the waste material into them at the highest allowable well head pressure The selection of the well head pressure is a matter which requires knowledge of the formation, knowledge of the cap rock, and the possible existence of faults in the cap rock.

(8) Economic Evaluation of Deep Well Disposal. Disposal wells, including surface facilities, can be very expensive disposal facilities. The costs depend upon the nature of pretreatment required, depth of hole, corrosivity of the waste, requirements of the regulatory agency, nature of the formation, and many other factors peculiar to the problem at hand.

THE WASTE DISPOSAL PROBLEM AT SARNIA REFINERY

Sarnia Refinery is located on the St. Clair River, which is 40 miles long, has a flow of about 200,000 cubic feet per second and, with Lake St. Clair and the Detroit River, drains a basin having a population of about 4,000,000 people.

The St. Clair River and connecting waterways carry a shipping tonnage exceeding that of any other waterway in the world. The region contains one of North America's most highly developed industrial complexes, and is also very highly developed for residential and recreational uses.

The waters are vital to the people and industry for domestic supply, sanitation, industrial use, fish and wildlife, and recreation. These waterways are international boundary waters and, for pollution purposes, come under the jurisdiction of the International Joint Commission. The objectives of this commission in part, specific to industrial chemical wastes of the phenolic and other than phenolic types, are as follows:

INDUSTRIAL WASTES

(1) Chemical Wastes - Phenolic Type. Industrial waste effluents from phenolic hydrocarbon and other chemical plants will cause objectionable tastes or odours in drinking or industrial water supplies and may taint the flesh of fish. Adequate protection should be provided for these waters if the concentration of phenol or phenol equivalent does not exceed an average of 2 p.p.b. and a maximum of 5 p.p.b. at any point in these waters following initial dilution. This quality in the receiving waters will probably be attained if plant effluents are limited to 20 p.p.b. of phenol or phenol equivalents.

Some of the industries producing phenolic wastes are: coke, synthetic resin, oil refining, petroleum cracking, tar, road oil, creosoting, wood distillation, and dye manufacturing plants.

(2) Chemical Wastes - other than Phenolic. Adequate protection should be provided if:

(a) The pH of these waters following initial dilution is not less than 6.7 nor more than 8.5. This quality in the receiving waters will probably be attained if plant effluents are adjusted to a pH value within the range of 5.5 and 10.6.

(b) The iron content of these waters following initial dilution does not exceed 0.3 p.p.m. This quality in the receiving waters will probably be attained if plant effluents are limited to 17 p.p.m. of iron in terms of Fe.

(c) The odour-producing substances in the effluent are reduced to a point that following initial dilution with these waters the mixture does not have a threshold odour

number in excess of 8 due to such added material.

(d) Unnatural colour and turbidity of the wastes are reduced to a point that these waters will not be offensive in appearance or otherwise unattractive for the afore-mentioned purposes.

(e) Oils and floating solids are reduced to a point such that they will not create fire hazards, coat hulls of water craft, injure fish or wildlife or their habitat, or will adversely effect public or private recreational development or other legitimate shore line developments or uses. Protection should be provided for these waters if plant effluents or storm water discharges from premises do not contain oils, as determined by extraction, in excess of 15 p.p.m., or a sufficient amount to create more than a faint irridescence. Some of the industries producing chemical wastes other than phenolic are: oil wells and petroleum refineries, gasoline filling stations and bulk stations, styrene copolymer, synthetic pharmaceutical, synthetic fibre, iron and steel, alkaline chemical, rubber fabricating, dye manufacturing, and acid manufacturing plants.

In order to approach or meet these objectives, the refinery utilized terminal separators for oily water, flue gas stripping plus biological oxidation for sour or phenolic water streams, sales for some selected spent caustic and incineration for the remainder. These streams resulted from an integrated refining operation which has grown today to 94,000 B/SD crude running capacity, a lube oil, wax and grease operation, and a $45,000,000 investment in petrochemical plants. The varied sources, volumes, and pollution potential of the streams presented a costly and complex problem in waste disposal and pollution prevention.

The oily water flow to the separators is about 50,000,000 IG/day, and no further consideration will be given to this waste water in this paper.

In the case of phenolic water and spent caustic, certain streams contributed about 90% to the pollution problem and disposal cost. To strip the phenolic waters free of sulphides for subsequent biological oxidation cost the refinery about $350,000/Year.

In view of the high cost of disposal, and the serious effects of accidental large concentration of phenols in the river, alternate schemes of disposal were investigated, and the most attractive of these was deep well disposal. Impetus was given to our study of deep well disposal when, in 1958, the necessity of disposing of an additional 350 B/D of spent caustic became apparent. This stream resulted from a petrochemical cracking operation and was not suitable for sales. The original neutralization facilities designed for this stream were not considered adequate for the job.

Two possible injection formations exist in the Sarnia-East Michigan Area; the Detroit River Group and the Cambrian Sand formation. Because of our knowledge of the Detroit River Group, and the costs of

drilling to this formation, a decision to drill one injection well and one observation well into this zone was made early in 1958. The Detroit River Group structure is shown in the attached structure sketch and may be described as rocks of middle Devonian Age. These rocks, related to geological time, are approximately 300 million years old, and are encountered at depths of 640 feet in the refinery area dipping to the west into the Michigan basin at the rate of 30 to 40 feet/mile, and outcropping in the limestone quarries at Ingersoll, Ontario, 100 miles to the east.

The Detroit River strata consist of porous dolomites with some anhydrite interbeds. This dolomite exhibits excellent inter-crystalline porosity (microscopic porosity between the grains and crystals)as well as good permeability, which is the ability to transmit fluids throughout the porosity.

In actual core analyses, the upper 200 feet of the Detroit River Group contains a net 100 feet of permeable sulphur water filled reservoir. This reservoir has an average porosity 15.5% and a permeability of 16.2 millidarcies.

Below this 200 feet within the Detroit River, permeability drops rapidly and the reservoir is ineffectual as an injection zone.

Large water bearing strata of rocks are common in sedimentary rock sequences throughout the world and are found at depths from a few feet to several miles, and vary in salt concentration from fresh to over 200,000 ppm with varying amounts of sulphur and other minerals.

The other extensive aquifer in the Sarnia Area is a Cambrian Sand at depths of 4700 feet in the refinery area. These rocks are primarily of quartz sand with some dolomite, and are immediately overlying the granite basement. Rather sporadic permeability conditions in the area make for a less attractive disposal project in this aquifer since the cost of drilling and completion would be increased ten fold as compared to the Detroit River project.

The first disposal well, subsequently called disposal well number 1, was located in the Chemical Products Area. The injection well and observation well were drilled in August 1958, and piping and surface equipment was installed by October 1958, when the well commenced operation. Originally the feed to this well was 15 B/H of spent caustic until October 1959, when phenolic water from the Chemical Products Unit was injected. The initial operation of this well fulfilled our best expectations; with only caustic going into the well, a well head vacuum of approximately 20 inches of water was maintained until the sour water was added. The amount of sour water going to the well was increased bit by bit until in February 1960, 80 B/H of water plus 15 B/H of spent caustic was being injected at 230 psig at the well head.

The observation well has been checked frequently since injection commenced and no formation pressure increase or contamination has been observed. The observation well is now checked about once per month.

Our experience with this first well was so good that we took steps to provide disposal well facilities for the other 300 B/H of phenolic streams in the refinery.

Based on the injectivity tests in the first well drilled and the required flow of the other wells, four more wells were drilled in Sarnia Refinery.

The four wells, Nos. 2, 3, 4 and 5, were drilled in the locations shown on the attached plot plan, and were completed by May 1960. Each well took approximately ten days to complete drilling and casing. The total cost of the entire project, including surface facilities, was about $190,000, of which the wells accounted for $55,000.

As each well was completed, it was tested for injection capacity up to the self-imposed limit to 400 PSIG well head pressure. Immediately it became evident that each well was different and none behaved like the original well.

The results of the tests were inconclusive because of the limited testing period as compared to the well life. Directionally, it appeared that the total injection capacity of the four wells would be about 200 B/H, against the 300 B/H required. Of the four wells, one took about 10 B/H, one started at 120 B/H and dropped to 80 B/H, the other two took about 55 B/H each, all at 400 PSIG well head.

Since our assumption that the injection formation was homogeneous over the area involved was supported by core and chip samples, we concluded that local formation damage because of the drilling was to blame. This led us into a program of well stimulation.

The net effect of this program, which included acidization, acid fracturing and, in one instance, sand fracturing was an increase in injection capacity from 200 B/H to about 250 B/H, spread over three of the four wells. The well taking 10 B/H was not significantly improved, the two taking 55 B/H each were increased to about 60 B/H, and the well which started at 130 B/H was brought back to 120 B/H.

These rates have continued for several months with only minor variations, and should represent the long-term injection capacity of the wells.

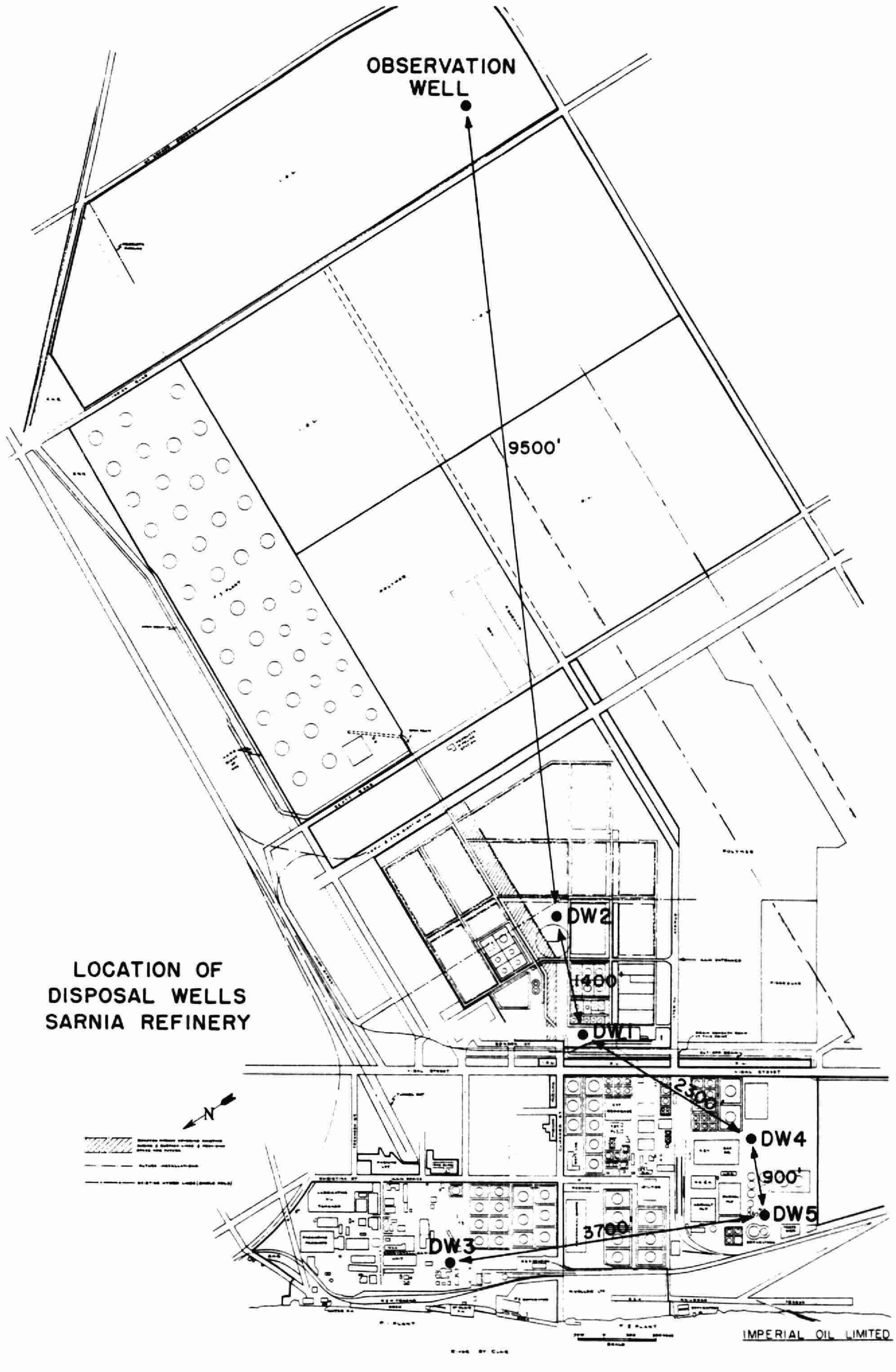
FUTURE DISPOSAL WELL OPERATION

Disposal Wells 1 and 2 are taking care of the disposal problem in the Chemical Products Area. Wells 3, 4 and 5 are partially satisfying the requirements of their areas. Because of this, the original disposal facilities must still be operated at a reduced rate and the full economic return on the wells has not been gained.

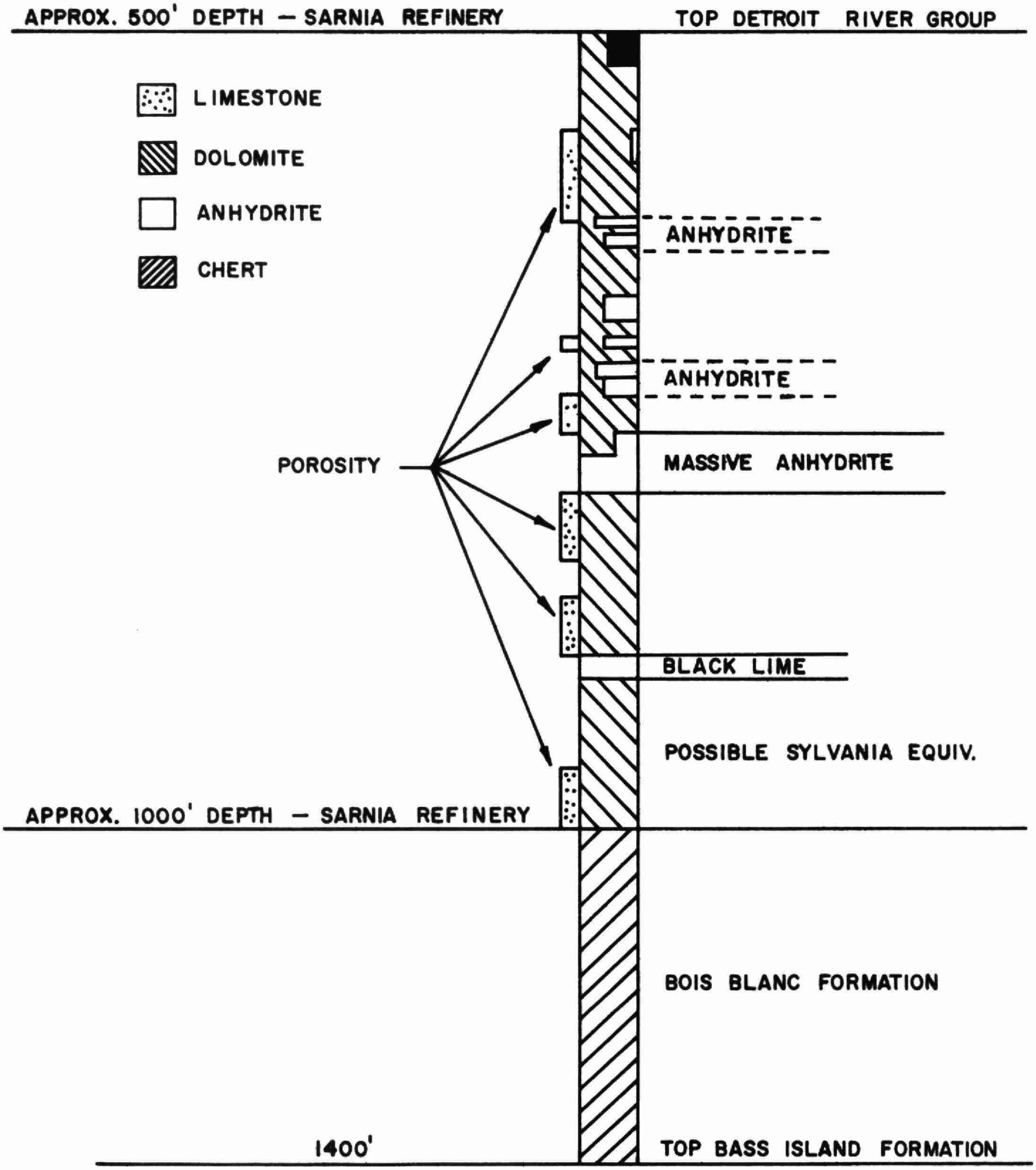
We have concluded that the expected injection rates, based on the rates obtained at well No.1, were optimistic by about 30%.

We have also concluded that well stimulation , while helpful, is not a substitute for inherent injection capacity.

In all probability, several more wells will be drilled because the whole project is still very attractive.



OBSERVATION WELL
9500'
DW2
1400'
DW1
2300'
DW4
900'
DW5
3700'
DW3
LOCATION OF DISPOSAL WELLS SARNIA REFINERY
N
IMPERIAL OIL LIMITED



—IMPERIAL OIL LIMITED—

MANUFACTURING DEPARTMENT | O A. DEPT. | SARNIA REFINERY

DRAWN BY: PETERSON	STRUCTURE SECTION	DATE: MAY 2, 1961
CHECKED BY:	DETROIT RIVER GROUP	DRAWER No. A—
APPROVED BY:	BOSANQUET AREA	DWG. No.
SCALE: 1" = 75' APPROX.	IMPERIAL CALVAN BOSANQUET 52 LRE	224 S.H.

EIGHTH ONTARIO INDUSTRIAL WASTE CONFERENCE

AT

DELAWANA INN, HONEY HARBOUR, ONTARIO.

BIOLOGICAL TREATMENT OF PHENOLS

by

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INTRODUCTION

Phenol and allied organic compounds, a prime target of pollution abatement activities for many years, have been and still are today a subject of much controversial discussion regarding their toxic and taste and odor causing effects. Whether or not phenol is really the culprit it is often made out to be is beyond the scope of this paper. If phenol in waste waters is to be destroyed or if the BOD derived from phenolics is to be essentially eliminated, there are effective and proven treatment techniques (1,3,6,7) available to do this. There is general agreement that biochemical oxidation offers an effective and comparatively inexpensive method for phenol destruction and BOD reduction. Investigations in this area have been of both a practical (2,7) and a more fundamental (4,5) nature.

The ultimate in biological treatment certainly has not yet been attained. Progress is continually being made particularly as our understanding of the fundamentals of biochemical processing increases and as new and more efficient equipment is being developed to keep pace with the advance of our process know-how. The purpose of this paper is to review the prior art in this field and to contribute to it on the basis of our experience and experimentation from both full and pilot scale tests.

The two most commonly used aerobic processes for the treatment of wastes, trickling filtration and activated sludge, and their variants, have been applied to the solution of this problem with unexpected success in some cases with respect to the remarkable reductions actually achieved and with disappointment in others. Actually, both types of processes can accomplish an

admirable and economic degree of treatment when properly applied. Proper application requires an understanding as to why these processes may have failed, in whole or in part, in the past; their limits of capability; and their particular advantages and disadvantages.

TOXITY AND ACCLIMATIZATION

If phenol is different at all, as compared with other organic substrates, it is different only because the material itself, in sufficient concentration, is toxic to unacclimatized populations of microorganisms more commonly found in nature or in biological waste treatment plants. The degree of toxicity attributable to phenol alone is often clouded by the presence of other compounds which may be even more toxic than phenol such as cyanides, sulfides, and ammonia depending upon their concentrations and which also have a retarding effect on biochemical reaction rates. Along with toxicity, we must also consider the variations in waste water characteristics that normally occur in any waste discharge and contribute shock loadings to the plant. Changes in waste concentration, temperature, and pH can be just as damaging as basic toxic retardation.

These problems can be reduced or eliminated by careful environmental control. This can be accomplished by proper feed preparation and treatment plant design to produce a regime which will yield an amenability to treatment comparable with sewage and other organic wastes. Once the approach to optimum environmental conditions has been established, the necessary microorganisms, which are not uncommon, will establish themselves and grow to meet the demands of the food supply imposed.

PHENOL AND BOD

It often appears that BOD is the neglected stepchild when the biological treatment of phenolics is considered. There is good reason for this. Biochemical oxygen demand is little understood by the average layman and industrial plant operator, it is considered a crude analysis by others, and the time consuming procedure involved precludes its use in day to day operating control of treatment plants. Phenol and chemical oxygen demand analyses are much more convenient. They can serve adequately to gauge treatment plant performance and assist in operating control. BOD is extremely important and useful, however, and its real value should not be overlooked. BOD concentration may be correlated with reasonable consistency to specific organics or chemical oxygen demand in simple industrial waste discharges. Most wastes are more complex, however, and frequently no correlation exists.

Persistently high reductions in phenols over a wide range of plant operating conditions are not necessarily followed by comparable reductions in BOD. An acclimatized biological culture can rapidly destroy phenol but the degree to which the oxygen demand of intermediate by-products may be satisfied will be dependent upon the overall process conditions employed.

Significantly, phenol when considered as BOD, appears to us to

be no different than many other types of BOD produced from a variety of sources. BOD data for phenolic wastes when combined with BOD information on a host of other wastes (including sewage, packinghouse, pharmaceutical, chemical, and several types of pulp and/or paper mill wastes) shows remarkably reasonable correlations with such basic process factors as loading and oxygen requirement for equivalent operating conditions. If these relationships continue to show good agreement then what we may learn on one type of BOD will be applicable to all types of BOD regardless of their source when defined in terms of fundamental and more universal process criteria.

Unfortunately, fundamental design criteria for biological treatment has only recently come into being and is still not commonly used or, in some cases, even accepted. The need for a more fundamental approach to the design of biological treatment plants became quite apparent when "rule of thumb" criteria normally proven adequate and generally universal for sewage treatment plant design did not produce satisfactory results when applied to the treatment of a majority of industrial wastes. Existing sewage treatment processes were and are sound but design criteria was not sufficient to size a treatment plant for a waste which was substantially different in characteristics from normal sewage.

LOADING

In the past, it has been the practice to define loading in terms of the quantity of BOD applied to or removed by a given aeration volume. This criteria does not allow for or recognize differences in BOD or mixed liquor suspended solids concentrations and temperature. A more rational approach is to consider loading in terms of the amount of BOD applied to or removed by a fixed quantity of biological culture which will yield an optimum physical environment. The most common parameter used for this is pounds of BOD per pound of mixed liquor or volatile mixed liquor suspended solids per day. The more closely we can tie in quantity of food matter with the quantity of microorganisms which can best handle this food matter for a given set of conditions, the more universal the parameter becomes. This is particularly true if we subscribe to the fact that the BOD bottle tests equate most all organic waste regardless of its source.

Why is BOD loading important? It is true that it is possible to operate at almost any loading but it is also apparent that some loadings are much more difficult to handle than others. We accept the fact that as BOD loading decreases there will be a continual increase in BOD reduction efficiency and oxygen consumption and a decrease in the quantity of excess biological sludge produced. Loading is a measure of the feeding rate to the microorganisms. When fed at an optimum rate, they react accordingly and produce a suspended biological solid with good flocculation characteristics and rapid settleability. When over or underfed they rebel and the result is a sludge of poor quality difficult to handle. Actually, as BOD loading increases

or decreases sludge quality can improve or deteriorate. A plot of sludge quality against BOD loading would show a series of optimums with respect to sludge settleability with each at a different loading range. These optimums have become operating points in activated sludge processing and have been sometimes designated by such names as high rate, modified, conventional, and total oxidation or endogenous treatment.

The key to successful operation and control of any activated sludge plant is the production of a high quality suspended solid with good settling characteristics. This is absolutely necessary if the maximum degree of treatment and flexibility are to be obtained in the smallest size plant. One of the major advantages of the activated sludge process over trickling filtration, which has permitted it to provide more treatment in a smaller plant volume, is that it lends itself to more precise measurement and control. Unfortunately there are many activated sludge plants where this control cannot be exercised due to poor sludge quality. This condition can often be directly related to a lack of appreciation of the importance of the loading factor in the sizing of the treatment plant particularly with respect to final clarifier area provided. When this occurs the plant generally operates itself and seeks its own equilibrium in a manner similar to that for trickling filtration.

TEMPERATURE

Figure 1 shows a graph of optimum loading for conventional activated sludge treatment with moderate mixing in the aeration tank as a function of operating temperature. Phenol has correlated well with many other types of organic wastes along the five-day BOD line. Biochemical reaction rates increase in a manner similar to that for chemical reactions as temperature increases. This is an important design parameter for industrial wastes where a wide range of waste water temperatures are encountered. Increasing temperature up to about 120°F is beneficial in two respects. Due to increased reaction rate, a fixed quantity of microorganisms can treat more BOD, while maintaining optimum conditions, resulting in smaller plant size requirements. Also, the endogenous burn-up of sludge appears to increase at a more rapid rate than the synthesis reaction resulting in less excess sludge production and wastage at higher temperatures. This also tends to be substantiated by the fact that unit oxygen requirement increases, at constant loading, as the temperature increases.

OXYGEN REQUIREMENT

Figure 2 shows a plot of oxygen requirement as a function of phenol loading at one operating temperature. When this loading is translated in terms of five-day BOD, the oxygen requirement for phenol correlates well with many other types of organic waste.

Oxygen supply is considered to be the third important design parameter for activated sludge treatment. As in the case of loading a more fundamental criteria is needed to describe oxygen requirements for the process so as to be universally applicable. Air requirement for a standard aeration volume or for a pound of BOD applied or

removed is not sufficient. These criteria do not allow for differences in BOD loading and temperature. A better parameter would be the pounds of oxygen required per pound of biological culture operating at a specific loading and temperature. Given the oxygen required per hour or per day and the design aeration volume it is possible to determine the size and number of aerators needed and to recommend the air required based on the oxygen transfer capability of the aeration equipment.

Aeration equipment has always played an important and often controlling part in the sizing of activated sludge systems. Liquid detention requirements for aeration, in the past, have been dictated in large measure by the inability of available, commercial aeration equipment to achieve high oxygenation capacities and not by the needs of the biological process itself. Given an unlimited oxygen supply capability, it is believed that only the BOD adsorption reaction rate and biological solids handling capacity need determine the liquid detention requirements for any activated sludge-system. If the basic BOD loading parameter is accepted, then the liquid detention requirements for aeration will depend only on the BOD concentration in the raw waste, the mixed liquor suspended solids concentration chosen to be maintained in the aeration system and the temperature. To be sure, liquid detention cannot be neglected altogether. Test work has demonstrated that minimum liquid detention requirements exist. It is believed that thirty minutes is sufficient for BOD which is largely of an insoluble or suspended nature such as sewage and that 120 minutes is sufficient for BOD which is largely soluble or in true solution such as phenol.

TRICKLING FILTRATION

While most of the foregoing analysis and interpretation of test results have been obtained by studies of the activated sludge process on various wastes many of these observations appear to apply equally well to trickling filtration. Still other observations may explain basic differences in these two modes of operation which will assist in the proper application of each. The limited adsorptive capacity of a trickling filter may explain why extremely low loadings are necessary when treating BOD which is largely soluble. At the same time, a trickling filter does not have the capacity to handle toxic wastes comparable to that for activated sludge. The two most common practical methods for controlling toxicity are by dilution and compositing. The trickling filter can reduce toxicity only by dilution and the use of recirculation while its compositing ability is practically nil.

Trickling filters should be considered for treating high volume, low phenol concentration wastes where the water is warm or heated. Table No.I presents design loadings which have been successfully employed in the treatment of phenolic wastes having concentrations of 50 ppm or less.

TABLE NO. I -

Recommended Design Phenol Loadings for Trickling Filters

Loading Lb. phenol/cu yd/day	Temperature °F	% Reduction Phenol	BOD
0.076	65	98.5	85
0.15	90	99	85
0.19	90	95	80
0.24	90	90	70

Effluents containing less than 1 ppm phenol have been consistently produced. Where applicable, the trickling filter offers a simple, relatively inexpensive, and trouble-free method of treatment. Table No. II presents some typical operating results from one plant treating refinery phenols.

TABLE NO. II -

Trickling Filter Performance on Phenol

Loading -0.08 lb. phenol/cu yd/day
-0.13 lb. BOD/cu yd/day
Temperature -70°F.

	Influent	Effluent	% Reduction
Oil, ppm	25 - 40	5 - 7	80 - 83
Phenol, ppm	30 - 40	0.5 - 0.7	98.5
BOD, ppm	175 - 200	25 - 30	85
Sulphides, ppm	10 - 15	-	100

Shock loads of phenolics and other toxic substances and high temperatures up to 120°F while destroying life in the upper two feet of the filter bed did not affect life deeper inside of the bed and the filter has always quickly recovered full effectiveness. While there is considerable argument concerning whether the trickling filtration or the activated sludge process is the better shock absorber, it has been our experience that either process, properly applied, will be about equally adaptable to handling shock loads.

CONVENTIONAL ACTIVATED SLUDGE.

As an example of the application of the principles and design parameters discussed in this paper we would like to present some of the results of recent pilot plant investigation on the treatment of weak ammonia liquor from coking operations. This waste has a high phenol concentration and contains other compounds which are normally considered to be toxic to microorganisms. Laboratory and small scale tests indicated that raw waste dilution would reduce toxic effects and thereby produce practical reaction rates. Further tests, see Table No. III, indicated that under proper conditions phenol could be destroyed in a very short time. As little as one hour was required to reduce phenols to less than 1 ppm.

TABLE NO.III -

Phenol Removal Rate

Phenol Concentration ppm	Temperature °F	MLSS Concentration ppm	Aeration Time* Minutes
287	65	900	180
287	65	2250	120
287	65	4500	60
287	65	6750	60
287	65	9000	60
250	50	3040	90
250	50	2950	75

* Time to less than 1 ppm phenol remaining in effluent.

The equipment used in this work included a round aeration tank utilizing a single D-O[R] Aerator followed by a clarifier for separating the biological solid from the treated effluent and recycling them to the aeration tank. The D-O Aerator is a turbine type mechanical aerator which uses mixing impellers to transfer oxygen from air introduced into the system through a sparger ring at the bottom of the tank. This type of aeration device is capable of attaining highest oxygenation capacities and transfer efficiencies. It also provides for superior mixing of the aeration tank contents which permits an approach to a complete mixed or homogeneous aeration system which is highly desirable for the creation of an optimum environment. Maximum compositing of the waste is achieved under these conditions which further reduces toxic inhibition and inherently modulates the effects of shock loading. The characteristics of the mixed liquor (the biological environment) approach those of the treated effluent.

Table No.IV shows an analysis of the raw waste before and after dilution along with that of the treated effluent. Once an acclimatized culture was produced and the BOD loading was brought into practical range this effluent quality was consistently produced.

TABLE NO. IV -

Conventional Activated Sludge Treatment

	Raw Waste	Dilution	Effluent
pH	8.7	-	7.6
Phenol, ppm	3560	890	0.65
Cyanides, ppm	17	4.3	2.0
Cyanates, ppm	2640	660	425
Sulfides, ppm	36	9	1.0
Ammonia, ppm	6880	1720	1270
Chlorides, ppm	6700	1675	1560
BOD, ppm	8450	2110	47

The operating temperature for most of the tests was 90-95°F. Optimum loading proved to be approximately 0.7 lb. phenol/lb. MLSS/day which correlated well with basic BOD loading data when converted to five day BOD. When the mixed liquor suspended solids in the system was maintained at 5000 ppm this was equivalent to a volumetric loading of 235 pounds of phenol or 380 pounds of BOD applied per 1000 cubic feet of aeration capacity per day. Volumetric loadings as high as 340 pounds of phenol per 1000 cubic feet of aeration capacity per day were employed without reducing phenol removal efficiency. However, foaming became excessive at these highest loadings and a better operation was achieved by backing off to the operating point indicated above. It should be noted that actual liquid detentions over these ranges varied from 2.7 to 5.0 hours based on the raw waste and dilution water flow only.

Oxygen requirements also correlated well with other wastes and the aeration equipment was required to achieve oxygenation capacities from 100 to 200 ppm/hour over the operating range tested. Despite the high mixed liquor suspended solids concentrations employed, the sludge volume index was usually about 125 indicating a good quality sludge. Excess biological sludge requiring wastage from the system amounted to less than 0.1 lb./lb. phenol removed.

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MILK WASTE TREATMENT

by

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The waste waters from milk processing plants are as amenable to treatment by the ordinary methods as municipal sewage if sufficient allowance is made for the higher BOD.

The BOD of milk is due almost entirely to its butterfat, milk sugar (lactose), and protein (casein, lactalbumin and lactoglobulin) components, each of which have somewhat different rates of biological oxidation. The approximate BOD (5-day, 20°C) of each 100 pounds of organic solids from whole milk is 84 pounds, from separated milk is 83 pounds, and from cheddar cheese whey is 56 pounds (1). These figures show the importance of keeping milk solids out of the waste waters by an effective program of waste prevention and waste saving if waste treatment, either in industrial waste treatment plants or in combined treatment with municipal wastes, is required.

It is usually desirable to segregate the liquid wastes from a milk plant for separate treatment. These include:

1) Sanitary wastes which should discharge to municipal sewers, if available, or to a septic tank and underground drain field.

2) Clean, uncontaminated cooling waters which should be separated and discharged to a storm sewer, or used to dilute the effluent from the waste treatment plant.

3) Excess separated milk, buttermilk, and whey which are high in BOD - 72,000 to 35,000 ppm - and so should not be dumped in the floor wastes but should be converted to saleable products,

or should be disposed of separately by spreading very thinly on land for its marked fertilizing value.

4) Drips, leaks and first rinses from milk processing equipment which should be saved and utilized or disposed of, otherwise than in the plant drains.

5) Wash waters from containers and equipment which go directly to the plant drains. If the above segregations have been made, they will carry most of the organic matter contributed by the milk plant.

Where strong caustic cleaning compounds are used, as in bottle washers or evaporators (vacuum pans), the effect of pH on the treatment plant or receiving stream can be minimized by providing for reuse of the caustic solution and/or for the equalization of its discharge over a considerable time.

The dairy industry has been informed about the importance of by-products utilization, waste prevention and waste savings by the activities of various official pollution control agencies and by various industrial groups, such as the Subcommittee on Dairy Waste of the Dairy Industry Committee, and the National Technical Task Committee on Industrial Wastes. As a result of these activities there has been a trend toward lower waste losses in connection with various dairy processing operations. With the use of reasonably modern equipment and careful operation, the approximate pounds of BOD which can be expected in the material lost to the floor waste for the most common processes in the dairy industry have been listed. (1 p.7). These 1959 standards indicate a standard loss of 5 pounds of 5-day BOD per 10,000 pounds of milk received, cooled and loaded into tank trucks. However, waste surveys at several milk receiving stations in New York State and Pennsylvania show daily losses of less than 2 pounds of BOD per 10,000 pounds of milk received, even for periods of 6 or more consecutive days. These plants had good maintenance of equipment, used drip savers on the can washers and collected product-saving prerinses of lines and other equipment.

For the waste prevention program and in the control of waste treatment plants there is need for a test that will supplement the BOD test and give results within hours instead of days. A modified dichromate chemical oxidation (COD) test which is a marked improvement over the original Rhame test and its modification by Eldridge, was developed in our laboratories and has been used for more than 10 years. In this test the replicate portions of the oxidizing acid reagent (10 ml) are measured much more accurately and quickly by using a glass syringe with controlled travel of the plunger; the heating time and temperature are more closely controlled by reducing the size of the sample to 2 ml or less so that ordinary Pyrex test tubes can be used and immersed in an oil bath; and the controls and several samples (six or more) in duplicate can be heated simultaneously. This reduces the spread between duplicates and improves reproducibility between different runs (1, p.17). With this method it has been possible to run the COD test on 6 samples in duplicate in about 2 hours.

COMBINED DAIRY AND MUNICIPAL WASTES

For many years it has been generally agreed that dairy waste can be treated successfully by any of the usual chemical or biochemical treatment processes used for municipal sewage. The treatment unit must have sufficient capacity to handle the maximum load. Invariably the troubles of municipal plants handling milk wastes have been caused by the dumping of large amounts of excess by-products, such as whey or skim milk, and the troubles disappeared as soon as over-loading stopped.

It should be cheaper and better to build and operate one treatment unit for combined wastes than two or more separate units. There is a growing realization by municipalities that they should assist in treating the wastes from industries on which the town bases its prosperity.

SEPARATE TREATMENT PLANTS

The treatment methods which are used for municipal wastes and which can be used for dairy wastes include septic tanks or digesters, chemical precipitation, trickling filters, modified activated sludge processes, waste stabilization ponds, and land irrigation.

Septic tanks or anaerobic digesters have been successful on a small scale (2) but have not given consistently good results under plant conditions. This is probably due to a failure to control temperature and agitation closely. Indications are that temperatures of 90° to 103°F with just enough agitation to prevent a scum layer are required for best results. Then the expected BOD reduction is 50% with 3 days' retention and 80% with 10 days' retention. However, if the tank is overloaded, it becomes acid and ineffective and is difficult to bring back to proper condition.

Chemical precipitation of milk proteins and other suspended matter with either aluminum or iron salts can give crystal-clear effluents which still may contain soluble lactose with considerable BOD. The lactose may be removed by fermentation (activated sludge) before chemical precipitation but this is complicated. The chemicals are expensive, the sludge is voluminous and difficult to dispose of, and as far as is known, these methods are no longer used.

Several variations of the trickling filter method have been used for dairy waste treatment for more than 30 years. At many small dairies, a batch process was used in which the waste waters were collected in a sump and recirculated over the trickling filter for at least the period of milk plant operation and sometimes for most of the 24-hour day. The treated waste in the sump might be discharged once a day and process repeated. Gravel, crushed stone, slag or ceramic tile were used in the filter to support the biological film.

Single-stage, low-rate trickling filters have not been as successful for dairy wastes as the two-stage, high-rate,

recirculating trickling filters, probably due to the high BOD content in some dairy waste waters - 1000 ppm to over 3000 ppm. The trend has been towards the use of relatively low (3.5 to 6-foot deep) filters with a very coarse-medium (3 to 3.5-inch size), large open underdrains, high flow rates, (20 to 30 mgd or more), and high ratios of recirculation to raw influent flow - for instance, 5 to 1 to 10 to 1 or higher. Preferably, storage capacity should be provided to obtain reasonably good equalization of BOD loading over the 24 hours. High ratios of recirculation tend to give a good load-equalizing effect.

Permissible BOD loading on milk waste trickling filters does not have a definite limit, but if a consistently good effluent, such as under 30 ppm BOD, is to be obtained, then the average 24-hour loading should not exceed 1 pound BOD per cu yd. With complete equalization of flow and organic loading, it is possible to double this loading.

Operating results have been good on four high-rate, two-stage recirculating trickling filters with two-stage split clarifiers (3). BOD reductions of 90 to 97% have been observed.

After World War II there was a feeling in the dairy industry that the construction costs of trickling filters were too high in relation to the cost of the milk plants themselves and that some cheaper satisfactory treatment method should be found if pollution abatement was to make rapid progress. Also a more flexible treatment method was desirable to handle the increased wastes during the relatively short flush season volume of milk.

Early attempts to apply the activated sludge treatment, as used in municipal sewage treatment, directly to dairy wastes had not been successful. Several plants using a combination treatment of chemical precipitation and aeration were in operation on dairy wastes and gave better results as the organic load was decreased and the air supply increased. With the realization that an adequate supply of dissolved oxygen for the BOD load was the primary requisite for successful activated sludge treatment of milk waste, pilot plant studies were undertaken at our Baltimore laboratories in 1946 with synthetic milk waste using both batch operation and continuous flow operation with 55-gallon drums as aeration tanks. Aeration was continuous and the activated sludge which developed remained in or was returned to the system. In the batch operation, aeration was discontinued daily for 1 to 2 hours while the sludge settled and the clear supernatant was removed. Due to daily sampling of mixed liquor for analysis, there was removal of suspended solids and the erroneous conclusion was drawn that there was no build up of excess sludge in the system even after weeks of continuous operation (always 5 days feeding and usually 7 days feeding each week). Good sludge formation with a healthy brown color, and fairly clear effluents, and 85 to 97% reductions in BOD were obtained with a variety of loadings and different aeration devices.

The Subcommittee on Dairy Waste of the Dairy Industry Committee was kept informed of progress in this modified activated sludge method and they sponsored a similar pilot plant study by Michigan

State College personnel at Ovid using milk plant waste. This study also showed satisfactory treatment.

E.F. Eldridge, a consultant to the Subcommittee at that time, in 1947, and on the basis of these pilot plant studies, remodelled the dairy waste treatment plant at Belle Centre, Ohio (4), for modified activated sludge treatment using careful sludge control. Results were very good. Raw waste with about 1000 ppm BOD was treated with about 3600 cu ft. of air per lb. BOD and yielded a final clarified effluent with less than 10 ppm BOD. In spite of the relatively large volume of air used, considerable excess sludge developed and was treated in a heated digester at about 120°F. Reportedly there was no discharge of humus from the digester during more than two years of operation.

In August 1947 at Springdale, Connecticut, a simplified dairy waste treatment plant using modified activated sludge was installed in connection with a milk bottling plant. (5). Being the first treatment unit of its kind, it underwent various modifications as experience was gained from its operation but the flow sheet has been unchanged for more than 10 years. Floor wastes pass through a combination sand trap, grease trap, screen chamber and weir tank and then to an underground pump pit. The wastes are pumped to an overhead weir tank for control of flow into the aeration system. The regulated raw flow plus makeup from the aeration tank is pumped through four Type XL-96 No.4 eductors and into the lower portion of an overground, vertical, cylindrical aeration tank of 15,000 gallons capacity. Blower-supplied air (45 cfm) is mixed with the waste in the external jets. The aeration tank overflows to a large vertical, cylindrical clarifier with a motor-driven spiral rubber-bladed scraper for bringing the sludge to a central discharge chamber from which it is pumped back into the aeration system. Excess sludge is discharged to an underground digester which overflows to the pump pit. The clear effluent from the clarifier passes through an effluent weir box and across the pump pit to the outfall line to the creek. At times of low raw flow, a float-controlled butterfly valve returns effluent to the pump pit for 100% recirculation.

For more than 10 years, this system has operated with very few upsets and with very satisfactory results. The raw waste has shown 800 to 1200 ppm BOD and the effluent about 8 to 30 ppm BOD. One-hour settled sludge volumes have varied from 40 to more than 95%. Air has been supplied at the rate of about 500 to 800 cu ft per lb BOD. At times in cold weather there has been considerable excess sludge and during warm weather there has been no discharge of excess sludge for periods as long as 3 months. Since insulating the lines and aeration tank, the temperature in the system has not dropped below about 70°F. The average retention time in the aeration tank is about 28 to 40 hours and about 5 hours in the clarifier.

The Dairy industry through the DIC Subcommittee on Dairy Waste was kept informed of the satisfactory results as they were obtained from the Belle Centre and Springdale treatment plants. As a result modified activated sludge-type treatment plants for

dairy waste were built and placed in operation, one in 1948 at Tonganoxie, Kan., seven in 1949 at Alexandria, Tenn., Dayton and Germantown, Ohio, Pinconning, Mich., Mill Hall, Spring Creek and Springboro, Penn., three in 1951 at Toledo, Ohio, and Dushore and Starrucca, Penn., four in 1952 at Grover, Hop Bottom, New Milford and Tioga, Penn., and two in 1953 at Morristown, New Jersey, and Newfoundland, Penn.

Minimum treatment plants using aeration and without separate clarifiers were installed in 1948 for cheese plant wastes at several Missouri plants. (6) (7). The results were not entirely satisfactory due to insufficient blower capacity and insufficient aeration tank capacity for the organic load.

As a result of successful treatment of dairy waste by the modified activated sludge method at Belle Centre and Springdale, the DIC Subcommittee in 1948 sponsored research at the Eastern Regional Laboratory, U.S.D.A., under the direction of Dr. S.R. Hoover and Dr. N. Porges on the chemical breakdown of milk solids during modified activated sludge treatment. By quantitative information on the oxidative changes, it was hoped to be able to design more effective and more economical treatment units. This group has contributed considerable insight into these oxidative changes so that this method of dairy waste treatment is on a sound basis. Under contract from the U.S.D.A. a modified activated sludge treatment pilot plant for dairy wastes was installed under the direction of Dr. R.R. Kountz at Pennsylvania State College in 1953. The results using suction jets and pressure jets were similar to those from the large number of similar installations previously built at various milk plants. A Kountz-designed plant using suction jet aeration for milk wastes was built at Port Murray, New Jersey, in 1954. This plant also used batch operation.

Apparently the organic load at Port Murray exceeded the oxidizing capacity of the air supply since excess sludge formed in the aeration tank and was discharged both as a large volume of heavy foam and as suspended solids in the supernatant at the time of the daily draw-off after settling.

Since 1953 quite a number of modified activated sludge-type treatment plants for dairy wastes have been installed. Of particular interest is the Horseheads, N.Y., plant (8) which started operation in 1956. The pressure jet aeration plant is designed for 130,000 gpd with 320 lbs BOD per day and detention times of 24 hr in the aeration tank and 3 hr in the settling tank. The air supply to the aeration tank in the original design was 1 cfm per lb BOD in the raw wastes. The air supply to the equalization tank and aeration tank has been increased to 520 cfm or 1.6 cfm per lb of design BOD. The results of a 7-day survey in May 1956 show an average raw waste volume of 65,800 gpd, 464 lbs influent BOD, 10.5 lbs effluent BOD, or 97.6% BOD reduction due to treatment. A 3-day survey in August 1957 showed 97.3% BOD reduction but a 3-day survey in November 1957 showed only 64.4% BOD reduction, probably due to suspended solids in the effluent.

The modified activated sludge-type treatment plant at Farmdale

Ohio, has been in satisfactory operation since 1955 and 24-hr composite samples of influent raw waste and treated effluent on two days each month show excellent BOD reductions - usually 95% or more in warm weather and 90% or more in the winter. This plant was designed with two 150 cfm blowers and No.4 pressure jets located outside two horizontal cylindrical aeration tanks. Average retention time in the aeration tanks has been 1 to 2 or more days. The raw BOD load has nearly always been less than the design 300 lbs BOD per day due to good waste savings and waste prevention at this cottage cheese plant. Whey is segregated and hauled away and first cottage cheese wash waters are disposed of otherwise than to the aeration system. One blower is used all the time and the second blower is used only part of the day. For more than a year the recirculation of mixed aeration tank liquor through the jets has been eliminated with little or no apparent effect on BOD reductions. In other words the air is introduced through the orifice of the No.4 eductor into a short length of 1-inch line and then is able to rise in the aeration tank. This has given a sludge with better settling properties.

While it was found that the capital costs for the modified activated sludge treatment plants were lower than for trickling filter plants of equal capacity, the power costs were higher and many milk plant operators felt that the cost of waste treatment by these methods was too high.

Encouraged by the success and low cost of ridge-and-furrow irrigation and spray irrigation for the disposal of cannery wastes during the short canning season, the dairy industry, beginning in 1949, has installed at least 43 spray irrigation systems and 29 ridge and furrow irrigation systems for waste disposal.

Ridge and furrow irrigation of dairy waste has been discussed by Schraufnagel (9, 10, 11). Four of these systems are in Minnesota and 25 are in Wisconsin. For ridge and furrow irrigation relatively flat land with reasonably good percolation rates is desirable. Wastes are discharged into a main or header ditch and then flow into the furrows which are nearly level, at a slightly higher elevation, and at right angles to the main ditch. The furrows are about one to three feet deep, one to three feet wide, and three to fifteen feet apart. There is a control gate in the main ditch and a dike to a height about three feet above the furrows surrounds the area of about 1 to 1.5 acres. The main ditch extends through at least two and almost always three similar areas at lower levels. When the waste level in the upper area rises to about 6 inches in the furrows, the control gate can be set to overflow into the next lower area and the second control gate set similarly.

Wastes may pass through a sand and grease trap before discharge by gravity or by pumping to the main ditch. The waste disappears by evaporation or by percolation into the soil to join the ground water or to be removed by drain tile at least 30 inches below the furrows or to be transpired by vegetative growth on the ridges and in the furrows.

Costs other than land vary from $300 to $3500 per acre

epending upon the need for pumping facilities, the distance of he area from the milk plant, and the amount of grading necessary. stimated minimum disposal rates vary from less than 3,000 to more than 22,500 gpad and depend largely on the porosity of the soil.

Reported maintenance costs are very low and in some gravity systems are much less than \$100 per year. No difficulties are reported for successful operation in 40°F below zero winter weather. Odor problems may occasionally arise in hot close weather, particularly with wastes containing fat. At one plant the occasional addition of nitrate appeared to control the odor. At a whey butter plant the odor was noticeable near the disposal area. This was the only odor problem observed at 12 ridge and furrow installations visited in late May 1961.

At most of the installations the cooling waters are not segregated and so the BOD in the waste is relatively low so that the heavy growth of algae may contribute enough dissolved oxygen to keep down odors. Frequently the header ditch was partially covered with a heavy scum layer which would tend to prevent the escape of odors.

Muskrat burrows through the dikes or to the drain tile may cause pollution of the receiving stream.

Due to the possibility of odor problems during warm weather, the Wisconsin Committee on Water Pollution recommends the use of ridge and furrow irrigation in cold weather and of spray irrigation in warm weather during the period of vegetative growth.

Apparently the first reported installation of spray irrigation for dairy waste was in 1949 at Donaldson, Tenn. This was followed by spray irrigation installations in 1950 at Bridgeton, N. J., in 1951 at Riverside (Camden), N. J., in 1952 at Pickerington, Ohio, and Berwick, Ont., and by many more, mainly in Wisconsin, so that there are now more than 43 installations of this type.

In spray irrigation, the dairy waste should be screened to remove large particles which could plug the spray nozzles, collected in a pump pit which is pumped nearly dry before the waste can go septic, pumped in a tight pipe line at sufficiently high pressure to be broken up by the rotating irrigation nozzle into very fine droplets and evenly distributed over the wetted area. This gives a very thin layer of waste on the exposed surface of vegetation and soil and may be regarded as nearly saturated with dissolved oxygen at this time. Some of the waste evaporates during passage through the air and some from the surface film. Most of the waste percolates into the soil and during the growing season much of this is absorbed by the root hairs and transpired through the leaves. The waste moves downward and laterally through the soil to join the ground water. Lateral movement is facilitated by field drain tile placed at least 30 inches below the soil surface.

There are many unanswered questions concerning spray irrigation. Soil varies greatly in its ability to absorb dairy wastes. At some locations the average application of less than 2,000 gpd results in ponding and at other locations the average application of more than

27,000 gpd for weeks did not cause ponding and run off. Undoubtedly soil porosity, the location of the water table, and the presence or absence of growing vegetation and its type are important factors. Other factors are puddling of the soil surface due to impact by large water droplets, changes in the physical structure of the soil (particularly those with clay particles) due to excessive sodium ions, and clogging of voids in the soil by heavy growths of microorganisms

Ponding which is continued for an appreciable time results in anaerobic conditions which may cause odor problems and the formation of ammonia and sulfides which are toxic to many plants. The lack of oxygen in ponded soil is harmful to many plants.

The best water tolerant cover crop may vary with different soils and different locations. Reeds canary grass is said to be very good for the Illinois and Wisconsin area.

Spray irrigation has been used for dairy waste disposal at a few plants in severe freezing weather all winter. Special precautions to prevent freezing of lines, sprinklers and pumps must be taken. Since a heavy ice coating may form, the sprinklers should be on long risers. A duplicate spray irrigation area for spring and summer operation, while the ice-killed vegetation is being replaced by growth from the roots or from reseeding, should be provided.

Reported costs other than land for spray irrigation installations vary greatly. The cost of a simple system of a pump, plastic line and one sprinkler on a tripod base which is moved daily from one area to another is only a few hundred dollars. On the other hand a system with duplicate pumps delivering 280 ft head through thousands of feet of header and lateral pipe buried below the frost line, with valve boxes and drain valves, risers and permanently mounted sprinklers may cost $1 for each gallon of the daily waste volume.

Operating costs for spray irrigation include power costs for pumping, repairs and maintenance of the pumps, lines, valves, and sprinklers, and labor costs for changing valve settings and mowing the heavy growth of grass.

Unless the BOD of the waste is exceptionally high, greater than about 3,000 ppm, it does not appear to create a problem with spray irrigation. There is no odor problem when spraying fresh milk waste. Ordinary cleaning and sterilizing solutions have not created a problem. However caustic solutions from bottle washing, vacuum pan and other special cleaning operations should not be disposed of through the spray system. Salt whey and sodium chloride solutions from zeolite softeners should be disposed of separately and not sprayed on land.

In spite of these limitations the comparatively low cost of land irrigation methods of dairy waste disposal make them well worth considering where suitable land is available.

WASTE STABILIZATION PONDS

Waste stabilization ponds for municipal wastes have been popular for new installations in the Great Plains states on account of the low cost of installation and operation, low rainfall in these areas, and the availability of suitable land. Where the winter is severe enough to form a continuous ice cover, the BOD loading should not exceed about 30 to 35 lbs BOD per acre per day if odor problems during the spring turnover are to be avoided. At Albany, Minnesota, combined municipal and milk wastes are treated in a stabilization pond with a calculated loading of less than 30 lb BOD per acre per day and no odor complaints are reported. Higher loadings reportedly were used at other locations and severe odor problems developed.

SUMMARY

The popularity of dairy waste treatment methods changes with the development of less expensive satisfactory methods. The two-stage, high-rate recirculating trickling filter method gives satisfactory treatment but has a high construction cost. This method was popular until in the late 1940's, the modified activated sludge method was shown to give satisfactory treatment with a considerably lower construction cost but a higher operating cost. Interest in the land irrigation methods began in the early 1950's and, where suitable land is available, the relatively low cost of construction and operation make these methods attractive with many installations in Wisconsin and Minnesota.

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SESSION NUMBER FOUR

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THE ROLE OF AUTOMATION IN INDUSTRIAL WASTE TREATMENT

by

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A gradually accelerating effort to correct the industrial waste treatment problems of North America has resulted in investigations of the specialized processes and mechanical equipment that are essential to the various phases of industrial waste treatment. The ultimate goal, of course, is the most efficient treatment of waste for the least capital investment and lowest operating cost.

Statistics show that, despite all this activity, we have barely scratched the surface. A construction program is badly needed, as well as development and modification of processes, so that present-day waste and the more exotic industrial waste of the near future can be more effectively handled.

From an instrumentation standpoint, treatment processes are following the same historical pattern as industrial processes did. Instrumentation has been helping to bridge the gap between batch and continuous processes. More importantly, instruments have been improving continuous processes to their present high degree of efficiency. For example, development of automatic control made practical the use of continuous fractioning towers in the refining industry, resulting in the abandonment of the old pot type stills. This, in turn, has resulted in improved petroleum products with the advantage of prices for all to enjoy.

Much the same comparison can be drawn between batch and continuous treatment of cyanide wastes. There are still some governmental authorities who insist upon the use of batch type processes for cyanide waste treatment in their area of influence. Others have abandoned this concept and openly encourage the use of continuous processing. As the size of our industries increases and, in turn, their industrial waste problem increases, the use of batch type processes becomes impractical, if not inefficient. It is inevitable that all industrial waste treatment processes will eventually be switched to continuous operation and, as such, will rely heavily upon modern automation.

Because of the tremendous scope of the field of automation and instrumentation, this discussion must be limited to certain specific areas. For purposes of this presentation, comments will be confined to the basic measurements of oxidation-reduction potential, pH and level control. Flow control is unquestionably important, but in general, wastes have to be accepted as they are delivered, permitting only limited application of flow control in industrial waste automation.

Oxidation-reduction potential is a milli-voltage measurement of a ratio. According to Fig. 1, other things being equal, the voltage will be proportional to the logarithms of the relative concentrations of the differently charged ions. It is measured by means of an electrode system, consisting of a reference electrode, usually the calomel type, and a noble metal electrode, normally platinum. Gold is used in solutions of cyanides which tend to poison platinum. It is further seen from the Nernst equation that if we take the hypothetical case of two units of product related to one unit of reactant, we will have a milli-voltage which is in proportion to the ratio of two. If, however, we have a total concentration of product of 100 units, and a total concentration of reactant of 100 units, and we increase the concentration of product by one unit, we then have the ratio of 101:100. In other words, we have a very small millivoltage change, even though the concentration change has been exactly the same in both cases. This serves to illustrate that oxidation-reduction potential is an excellent indicator of the ratio of product to reactant when the total absolute quantity of each is small, but a poor indicator of the situation when the actual concentration is high. The result is that we have a device which is tremendously sensitive in detecting small changes in concentration, provided the actual concentration is small. It is only a fair indicator of concentration changes when the absolute concentrations are high.

The Nernst equation for the oxidation of cyanides to cyanates takes the form shown in Fig. 2. Complete conversion of cyanates to carbon dioxide and nitrogen takes the form shown in Fig. 3.

On the plot of the data shown in Fig. 4, two flat spots will be noticed. The first indicates the point at which cyanides have been oxidized to cyanates and the second shows where the cyanates have been further oxidized to carbon dioxide and nitrogen. At the point where this occurs, there could be a considerable difference

between the actual concentration of oxidants as compared with reductants, even though the essential reduction has been achieved. This means that oxidation-reduction potential is an excellent operating tool but a poor substitute for laboratory analysis.

The relatively wide tolerance in actual concentration of oxidant works to our advantage in that each waste, depending upon its constituents, will have a slightly different oxidation-reduction curve. It is not normally practical to predict what these curves are, but they can be definitely determined through laboratory titrations. Therefore, it is customary to use an instrument of sufficiently broad range to cover the anticipated span and then arrive at the actual set points of the controllers by laboratory analysis.

A typical oxidation-reduction potential control system for oxidation of cyanide, as shown in Fig. 5, consists of the controller, a device for adding chlorine, and electrodes installed at the point where the desired stage of the reaction is to be measured. The method of adding chlorine can vary from simple gaseous sparging of chlorine in large installations of extremely high speed agitation to the use of conventional chlorinators or hypochlorinators. Control of chlorine addition can be either electric or pneumatic.

Since the oxidation from cyanide to cyanate is virtually instantaneous, there is no problem in locating the first-stage electrodes where there are two stages of oxidation or where a second stage is to be handled by atmospheric oxidation. Where it is desired to combine the two into a single-stage process, the electrodes should be located at a point which represents measurement after approximately one hour of mixing.

The pH is, by definition, the logarithm of the reciprocal of the hydrogen ion concentration to the base ten. As such, it is also a nonlinear measurement. Its nonlinearity bears a similarity to oxidation-reduction potential. If we consider that a pH electrode system consists of the same calomel electrode that was used in oxidation-reduction potential measurement and a glass electrode which is specific to the hydrogen ion concentration, it can be seen that pH is nothing other than the oxidation-reduction potential of two specific ions, namely, the hydrogen ion and the hydroxyl ion. It is an activity coefficient and not a concentration coefficient; that is, it does not measure the ability of the acid to neutralize alkali or vice versa. The pH has been found through the years to be significant in many reactions and, as such, is used in the control of the treatment of chromate, cyanide and biological waste treatment processes. Recently, a pH measuring system was developed which eliminates the use of a preamplifier, greatly simplifying the present pH measurement and control systems. The control system is nearly identical to that used in oxidation-reduction potential, consisting of a measuring electrode, recording controller, and a means of adding the correct amount of reagent through a feeder or a valve.

One caution is to be observed in all control systems involving oxidation-reduction potential or pH. The measurement must be made

at a point where the reaction has been completed to the desired degree. This becomes extremely difficult to judge where lime is used as a neutralizing agent. This material dissolves very slowly and, therefore, it's hard to get a true pH measurement. Experience indicates that most effective control of pH is achieved with liquid reagents, such as caustic or acid, which are essentially dissolved, dispersed and react immediately. While economics may dictate the use of a material such as lime, the problems involved in good control make the economic advantages somewhat questionable.

A pH control system for wide swings in pH has been developed. It consists of a so-called gap action floating controller and a conventional reset controller (Fig. 6). With this system, two valves are used. One valve has a large capacity and will determine the basic reagent requirement. It is automatically adjusted in response to excursions of the measurement beyond the control band. The smaller valve will essentially trim the quantity of reagent required and thereby achieve fine control. This system makes up for the virtual impossibility of building a control valve which will not only add large quantities of reagent for large excursion, but at the same time, control pH to a very minute degree about the control point.

Since many small treatment plants will continue on batch operation, it is well to consider the benefits of applying instruments to this type of process. Through a system of level measuring instruments which will determine when a batch tank is full, and pH and oxidation-reduction potential instruments, a batch tank can be automatically filled, treated with alkali and chlorine and dumped - all without the help of an operator. The level instrument admits waste to the proper unit and then diverts it to the empty one when the first is full. It then initiates the addition of alkali to raise the pH to the desired 8.5 or above, then adds chlorine until the desired oxidation-potential value is reached. In this case, an interrupter type system is used which is entirely electric. A small amount of the agent is added, then stopped and allowed to mix. If the measurement has achieved the desired range of values following a minimum mixing time, no further addition takes place and the next sequence in the operation is then initiated. If, however, the measurement has not reached the desired value, another increment of reagent is added and the sequence is repeated until such time as the correct value is reached. The waste can be held in the tank for a given period of time, before being automatically dumped and the cycle repeated. Instrumentation is relatively simple and inexpensive, and makes the batch type operation much more efficient in terms of reduction of both manpower and tank capacity. Fig. 7 illustrates such a scheme designed for the waste treatment plant handling wastes from aircraft parts manufacturing operations. The flow controllers operate so as to maintain the desired ratio of acid, chrome, and cyanide wastes while at the same time maintaining a constant flow rate to the clarifier. This arrangement can be modified to handle almost any number of tanks from two up to whatever the installation might require. A system similar to this has been operating for many years on cyanide wastes at Oneida, Ltd., Oneida, New York.

The application of these control devices to industrial waste treatment plants has gradually broadened through the years, but it is by no means universal as yet. If we consider that universal treatment of industrial wastes is nearly inevitable and that the costs of such treatments are inevitably chargeable only to overhead, we must be prepared to build plants which operate at maximum treatment efficiency for minimum expenditures. The adaptation of controllers to either relatively small batch or larger continuous processes can make a contribution toward this end which far exceeds their initial and operating costs. In one case, it was possible to reduce the manpower requirements on a cyanide waste treatment plant from eight men to two men per 8-hour shift, with the plant operating automatically for the third shift. Similar results have been obtained in almost every instance where pilot plants have been run prior to the construction of the final treatment units.

Although the improvements mentioned above can unquestionably be achieved, it would be unwise for any industry to acquire equipment for automation which was beyond the comprehension of the personnel who would operate it. Therefore, it almost inevitably follows that while the adaptation of modern automation to waste treatment plants will reduce manpower, it requires an improvement in the quality of manpower. This is not too severe a problem, since any industrial waste treatment process of major consequence almost certainly requires at least part-time attention by trained chemists or engineers.

All of these comments generally apply to wastes from the metal working industry, but are equally applicable to waste processes involving biological treatment. The latter are similar to those experienced in conventional municipal waste treatment.

Industries faced with the problem of industrial waste treatment should give serious consideration to the use of proper instrumentation for these units for operating economy as well as public relations. Proper application of this type of equipment will bring incalculable benefit both to the industry and the regulatory authorities.

$$E = \frac{RT}{nF} \log_e \frac{A^{++}}{A^{+}} + \frac{RT}{nF} \log_e \frac{B^{--}}{B^{-}} + \frac{RT}{nF} \log_e \frac{C^{+}}{C^{-}}$$

E = Solution Potential

R = Gas Law Constant

T = Absolute Temperature of the Solution

F = Faraday's Constant

[ ] = Activity of the ions A, B, or C

n = Number of electrons difference between the tw› states

FIG.1

$$NaCN + 2NaOH + Cl_2 \longrightarrow NaCNO + 2NaCl + H_2O$$

$$CN^- + O^{--} - 2\ \text{electrons} \longrightarrow CNO^-$$

$$2Cl^0 + 2\ \text{electrons} \longrightarrow 2Cl^-$$

$$E = \frac{RT}{2F}\log_e\frac{[CNO^-]}{[CN^-]} + \frac{RT}{F}\log_e\frac{[Cl^-]}{[Cl_2]}$$

FIG.2

$$2NaCNO + 4NaOH + 3Cl_2 \longrightarrow 6NaCl + 2H_2O + 2CO_2 + N_2$$

$$2CNO^- + 2O^{--} - 6 \text{ electrons} \longrightarrow N_2 + 2CO_2$$

$$6Cl^0 \qquad + 6 \text{ electrons} \longrightarrow 6Cl^-$$

$$E = \frac{RT}{3F} \log_e \frac{[N_2]}{[CNO^-]} + \frac{RT}{F} \log_e \frac{[Cl^-]}{[Cl_2]}$$

FIG.3

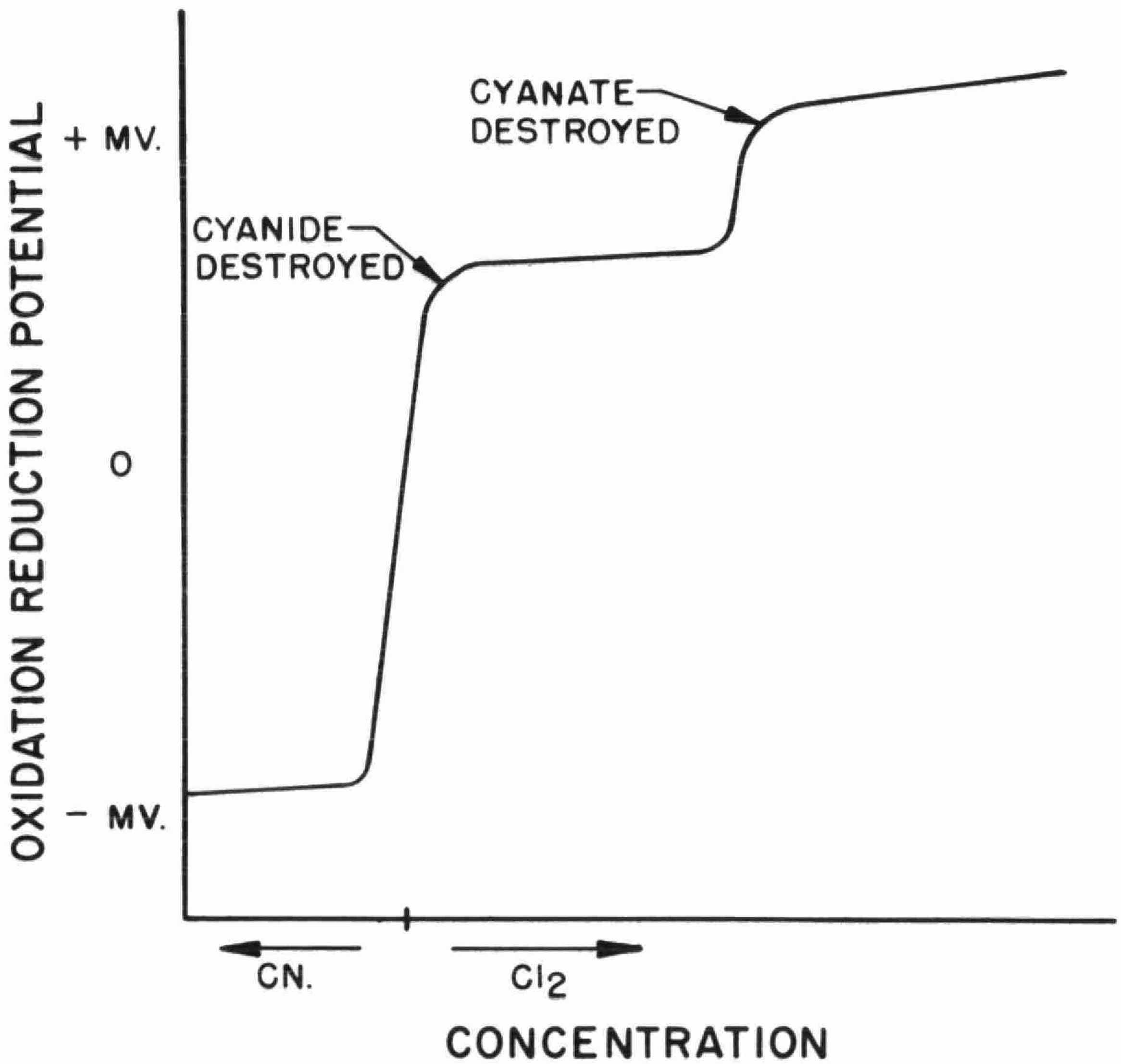
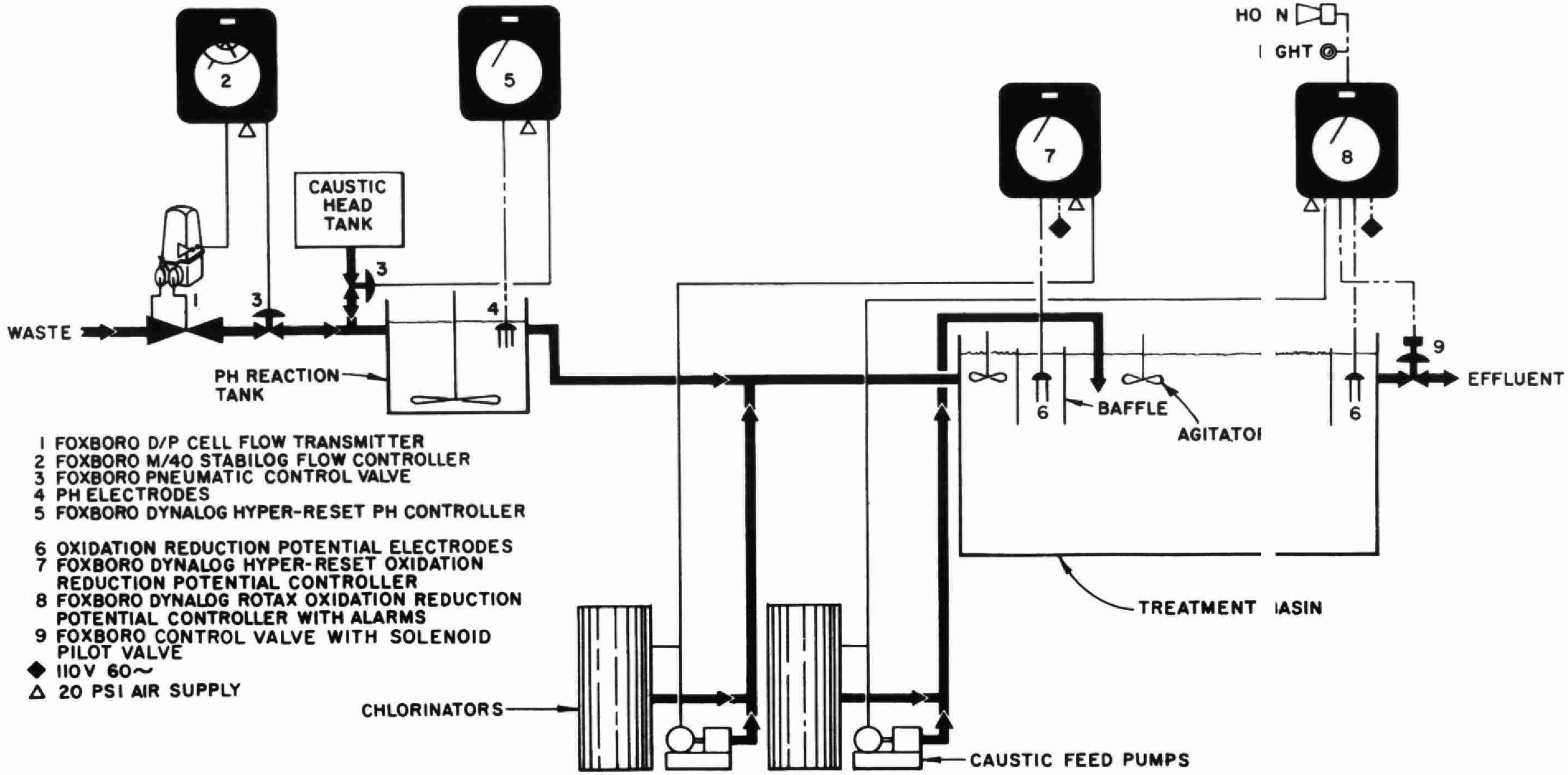
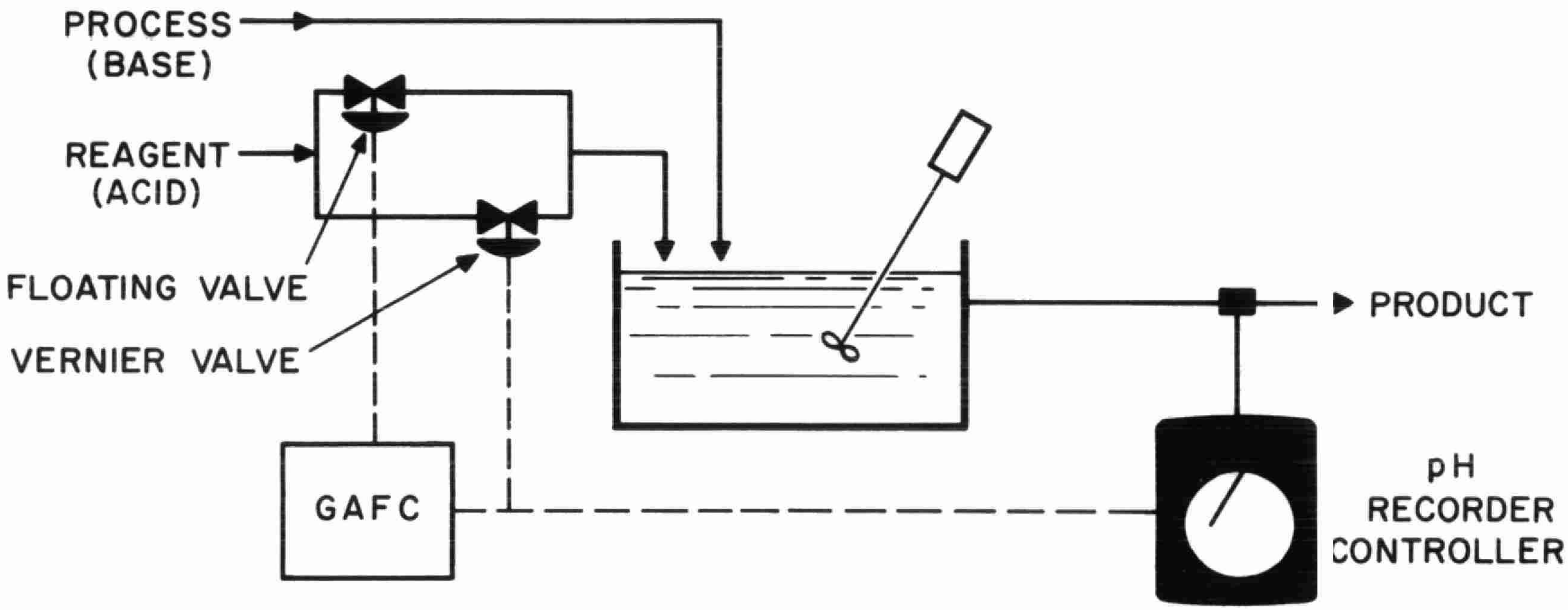

CYANATE DESTROYED
CYANIDE DESTROYED
OXIDATION REDUCTION POTENTIAL
+ MV.
0
− MV.
CN.
Cl_2
CONCENTRATION

FIG.4



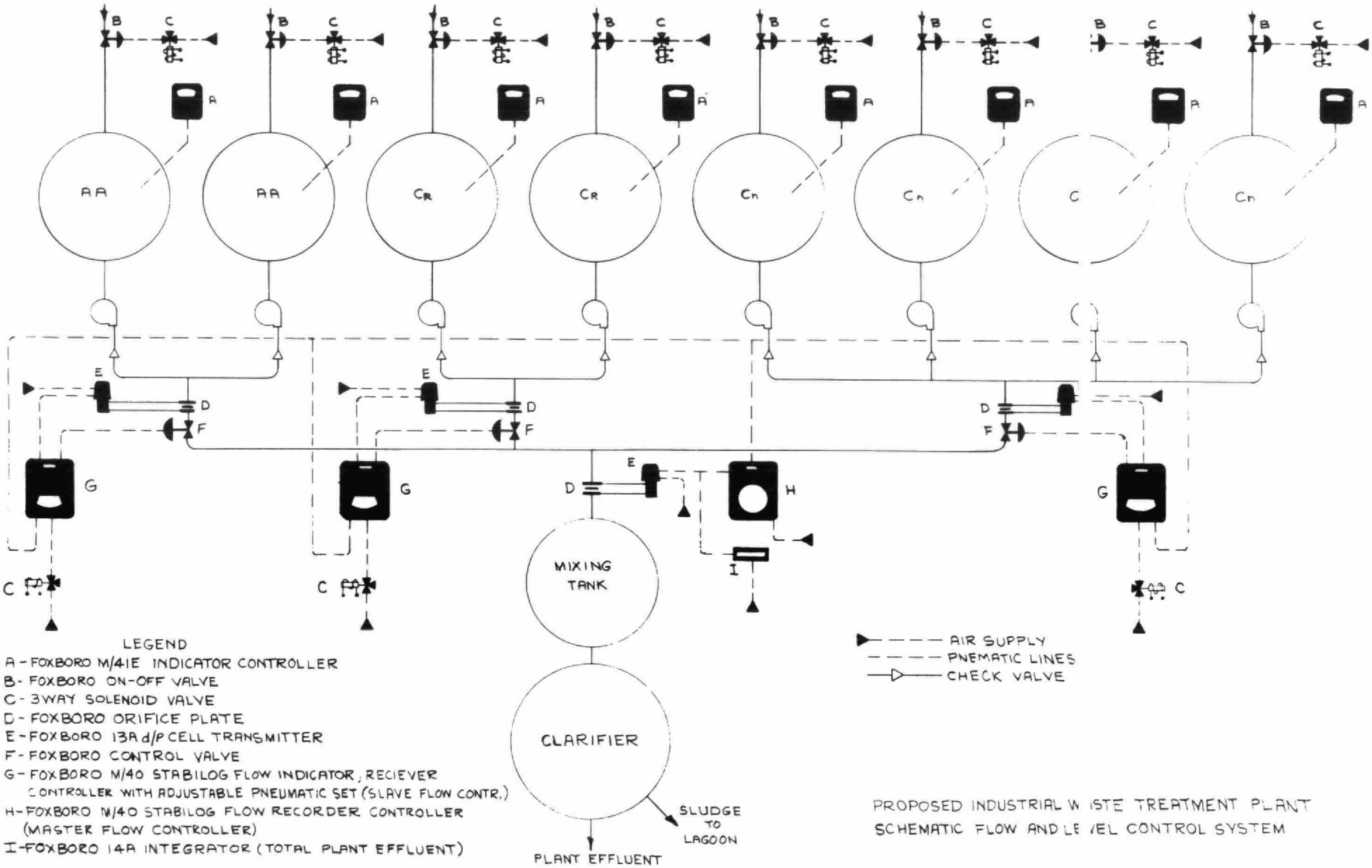
Application of Foxboro Instrumentation to Cyanide Waste Neutra ization Plant

FIG.5



Schematic Diagram of Wide Range pH Control System

FIG.6



B
C
A
AA
AA
CR
Cn
C
E
D
F
G
H
I
MIXING TANK
CLARIFIER
SLUDGE TO LAGOON
PLANT EFFLUENT
LEGEND
A - FOXBORO M/41E INDICATOR CONTROLLER
B - FOXBORO ON-OFF VALVE
C - 3WAY SOLENOID VALVE
D - FOXBORO ORIFICE PLATE
E - FOXBORO 13A d/P CELL TRANSMITTER
F - FOXBORO CONTROL VALVE
G - FOXBORO M/40 STABILOG FLOW INDICATOR, RECIEVER CONTROLLER WITH ADJUSTABLE PNEUMATIC SET (SLAVE FLOW CONTR.)
H - FOXBORO M/40 STABILOG FLOW RECORDER CONTROLLER (MASTER FLOW CONTROLLER)
I - FOXBORO 14A INTEGRATOR (TOTAL PLANT EFFLUENT)
AIR SUPPLY
PNEMATIC LINES
CHECK VALVE
PROPOSED INDUSTRIAL W ISTE TREATMENT PLANT
SCHEMATIC FLOW AND LE EL CONTROL SYSTEM

FIG.7

CONFERENCE DELEGATES

PLATING WASTE TREATMENT AT GENERAL MOTORS OF CANADA LTD., OSHAWA

S.J. TAYLOR.

by

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General Motors of Canada, Limited, Oshawa, manufactures several well-known models of cars and trucks. In the manufacture of various components of these vehicles, a number of processes such as plating, anodizing, battery and radiator manufacturing are carried out. These processes release various acid, alkali and toxic wastes.

General Motors have, in recent years, taken steps to minimize and to treat these wastes before discharging them to the city sewer system.

Due to the distances involved between plants and the relatively few manufacturing operations that produce objectionable wastes, the policy has been to install waste treatment facilities as an integral part of and adjacent to the process producing the waste.

In 1957, when battery manufacturing equipment was installed, waste treatment equipment was included.

This paper will deal with the work done in our Plating Department to control and treat wastes from these operations.

Prior to 1958, plating at General Motors of Canada, Limited was done on semi-automatic machines except for one automatic zinc plater which was installed a few years previous. In 1958, a program was begun to install one copper-nickel-chrome plater, one nickel-chrome plater and one aluminum anodizer. This work was completed during the Summer of 1959.

It was recognized that, due to the emphasis being placed on the control of plant effluents and the importance of efficient operations, here was an opportunity to ensure that our waste control and treatment facilities would be built into the equipment and would fill all local requirements.

One of the most important considerations when dealing with plating wastes is to take all practical steps to eliminate or minimize the wastes. After this has been done, the problem is to engineer an efficient method of treating or reclaiming the remaining wastes.

First, we will deal with the methods and equipment used at the plating machines to separate and reduce the waste flow.

When a rack is removed from a plating or anodizing bath, it is allowed to drain over the tank for at least one cycle before being moved to the next tank.

Immediately following each plating tank, there is a still rinse tank sometimes referred to as a save rinse. The solution from the still rinse tank is returned to the plating tank by means of a small pump which operates when the level in the plating tank drops due to evaporation and drag-out. Condensate is used as make-up for the still rinse tanks. These two features reduce drag-out and save plating chemicals.

Countercurrent or counter flow rinsing is used after cleaning, bright dipping, plating and anodizing stages where possible. This type of rinsing makes use of multiple rinsing tanks in series, with fresh water entering the final rinse tank and following from tank to tank, until it reaches the first rinse tank. From here, it flows to the waste sump for delivery to the waste treatment.

Spray rinses are installed over most of the rinse tanks (<u>Slide 1</u>) to spray fresh water over the work as it is being lifted out of the tank. The spray is actuated by a solenoid valve which is energized when the rack begins to lift. This type of rinsing is very effective and uses very little water.

Drain pans are used where required to catch the dripping solutions from racks during transfer (<u>Slide 2</u>) between tanks. The solution is drained back to the process tank. This saves chemicals and also reduces wastes.

Water purity in the rinse tanks is controlled by conductivity cells immersed in one of the rinse tanks in each of the countercurrent rinsing assemblies (<u>Slide 3</u>). The allowable contamination of the rinse is determined and the conductance is measured. This value is set on the controller (<u>Slide 4</u>). When the contamination exceeds that allowed, the controller actuates a solenoid-operated valve in the water line and water is fed to the last tank. Thus, water is only used when required and the human element of turning the water on and off and judging the quantity required is removed.

Water is added to the rinse tank through a perforated plastic pipe along the bottom of tank. An aerator is installed in the line at the tank. This provides an excellent siphon breaker and also air agitation in the rinse tank when water is being added. Additional agitation is also used in some tanks by means of a centrifugal blower. Water from heat exchangers is used in rinse tanks before being discharged.

On one counter-flow rinse system consisting of two rinse tanks after a cleaning stage, water consumption was reduced from an average of 154 to 32 cubic feet per eight hour shift using a conductivity controller. This is an example of the reduction in water usage possible using the methods of control outlined above.

All cleaner, copper plating, anodizing, bright dipping and chrome plating tanks are ventilated using a push pull system. The exhausted air is washed in air washers to remove harmful chemicals. The water from these air washers is pumped back to the waste treatment area - pH control is installed on one washer that washes fumes from a highly acidic bright dipping solution. This maintains the wash water at a slightly alkaline level and improves the efficiency of the washer.

The foregoing discussion has pointed out waste control measures taken at the plating machines. These have been very effective in reducing drag-out, providing for a more efficient rinsing system, preventing leaks and losses of valuable chemicals and also salvaging solutions.

The waste treatment process used requires that each type of waste be kept separate prior to treatment. In the case of cyanide and acid wastes, of course, this is a necessary safety measure.

The plating machines are installed in large pits (Slide 5). These pits are constructed of reinforced concrete and lined with acid resisting brick and mastic. You will note that there is no connection from the pit to the plant sewer system. Small dykes separate the pit into areas depending on the types of waste in the process. The slide illustrates this construction and shows this particular pit, separated into alkali, cyanide, acid and chrome waste areas. All wastes overflow or are dumped from tanks in these areas and flow to sumps. Float controlled duplex pumps pump the waste from the sumps through separate lines to the waste treatment area. The sumps provide enough capacity to serve as initial surge and equalizing tanks. However, the main advantages of the foregoing are that the wastes are separated and it is impossible to discharge wastes to the plant sewer system without first going through the easte treatment.

The waste treatment equipment was designed to handle flows of acid, alkali, cyanide and chromium bearing wastes. The quantity of these wastes was determined by a survey conducted by an outside firm. This survey was completed before the plating machines were installed. The waste flows were estimated from experiments done to determine drag-out and previous experience or dumping frequencies required of alkali cleaners and other solutions.

The waste treatment was designed to treat a combined flow of 300 gallons per minute which would consist of 12 gallons per minute of cyanide, 20 gallons per minute of chrome and 268 gallons per minute of acid and alkali wastes combined. These flows are about 25 per cent greater than those arrived at in the survey to provide for surges and possible future expansion.

Water quality objectives for the effluent were chosen which would be consistent with those general requirements laid down by the City of Oshawa and the Ontario Water Resources Commission.

The waste treatment can be described generally as a continuous treatment automatically controlled process. This is in contrast to the larger batch type systems in use in some plants, including several U.S. G.M Divisions. The continuous process seems more suitable when operated as part of the plating process. It is divided into three parts which will now be described in detail.

CYANIDE WASTE TREATMENT

The cyanide treatment system consists of a primary and a secondary stage (Slide 6). All cyanide bearing wastes are pumped from the sumps at the plating machines into the first tank. Each stage is of sufficient size to provide a retention time of two and one-half hours. A mixer is installed in each stage to provide a high rate of agitation.

The first tank is equipped with one pH controller recorder which controls the addition of a 50 per cent solution of sodium hydroxide to adjust the pH and one oxidation reduction potential controller recorder which controls the addition of a solution of Sodium Hypochlorite. The electrode assemblies are mounted in the tank while the instruments are located in an adjacent control room. The cyanide wastes are converted to cyanate and flow over a weir into the second stage.

The second tank is equipped with the same instruments as the first tank. Here the cyanate is converted to Carbon Dioxide and Nitrogen. The treated wastes then flow to the second final neutralizing basin.

Slide 6 shows a flow diagram of the cyanide treatment unit. Provision is made to divert the cyanide wastes to a storage tank. This is necessary when concentrated wastes, such as spent zinc cyanide bath are being received. These concentrated wastes are metered into the treatment tank during normal operation using the cyanide metering pump. The normal waste flow can also be stored temporarily if a failure in the equipment occurs. This is then pumped back to the treatment tank using the cyanide transfer pump.

The two stage treatment provides a safety factor in that if one stage becomes inoperative, the other can provide sufficient treatment.

CHROME WASTE TREATMENT

Chrome bearing wastes are treated in a single tank. This tank

is of sufficient size to provide a retention time of one hour.

A mixer is installed on this tank to provide agitation. A pH recorder controller adjusts the pH of the wastes by the addition of concentrated sulphuric acid and an ORP recorder controller controls the operation of a dry chemical feeder which adds Sodium Metabisulphite to the treatment tank. The Hexavalent Chromium ions are reduced to the trivalent state. The treated waste then flows to the first final neutralizing basin. Slide 7 shows a flow diagram of the chrome waste treatment unit. Provision is also made here to store wastes as described for the cyanide treatment system.

ACID-ALKALI NEUTRALIZING

All acid and alkali wastes flow to the first of two final neutralizing basins. Each basin provides a retention time of 15 minutes. A turbine type mixer is installed on each basin to give a high rate of agitation.

Slide 8 shows a flow diagram of the neutralizing system. Wastes that have a high alkali content are stored in a 10,000 gallon holding tank. Strong acid wastes are stored in a 5,000 gallon holding tank. The average pH of the combined acid and alkali rinse wastes is 2.75.

Each basin is equipped with a pH recorder controller. Originally a 50 per cent solution of Sodium Hydroxide was added to each basin to adjust the pH. However, since large volumes of highly alkaline cleaner solutions are dumped at regular intervals, it was felt that a saving of Sodium Hydroxide could be made by storing the waste cleaners and adding them slowly to the first neutralizing basin.

The pH controller was employed to do this and we feel that the system arrived at is rather unique and can be described as follows: a high limit of pH 5, a low limit of pH 2.2 and a narrow band control of pH 3.25 to 3.75 are set on the controller. Normally, the acid and alkali wastes are fed directly to the first neutralizing basin from the sumps at the plating machines when the pH is within the narrow band control range. However, if the pH exceeds the high limit of 5, the alkali wastes are fed to the alkali storage tank while the strongacid wastes are fed to the neutralizing basin. This is done automatically by air operated valves in the incoming lines controlled by the pH equipment and continues until the pH returns to within the narrow band range. Similarly, if the pH drops below the low limit, acid wastes are diverted to the acid storage tank. Normally, the pH is maintained within the narrow band range by the automatic addition of strong alkali wastes from the storage tank. This type of control on the first basin takes care of acid and alkali surges and accounts for a considerable saving of sodium hydroxide. In fact, the usage of sodium hydroxide was reduced by one-half following the installation of this control feature. From the first neutralizing basin, the wastes flow to the second basin where the pH is adjusted to 6.5

using a 50 per cent solution of sodium hydroxide. It should be pointed out that if the equipment in either basin fails, total pH adjustment can be done in the other by resetting the instruments since provision is made to add sodium hydroxide to the first basin.

GENERAL

The waste treatment facilities employ two persons, one in charge of general operation, maintenance and calibration of instruments and controls and one chemical analyst whose duty consists of checking incoming and treated wastes for correct treatment. General maintenance of pumps, mixers, etc. is done by the people responsible for repairs in the plating section.

Samples of treated wastes are taken from the cyanide and chrome destruction tanks and the second neutralizing basin twice daily. These samples are checked for cyanide, hexavalent chromium, residual chlorine, suspended solids and pH. Other tests for total solids, cyanate, etc. are made periodically. These tests reveal that during normal operations, the cyanide and hexavalent chromium ions are totally destroyed and the average pH of the effluent is between six and seven. A detailed record of all test results is kept in the treatment control room.

A continuous type of treatment process requires extensive instrumentation and control equipment. A central control panel houses the pH and ORP recorder controllers for the cyanide and chrome destruction and the final neutralizing process described earlier. An alarm system indicates high and low points set on all controllers and also pump failures, high and low levels of liquids in holding tanks and treatment chemical tanks. The instrument panel also contains controls with which the operator can divert all or any one of the incoming wastes to the storage tanks.

The waste treatment area is located in the same building as and within 75 feet of the plating machines. The area is totally enclosed on all sides and covers an area of 1200 square feet of floor space. In order to conserve floor space, the Sodium Hydroxide storage, waste chrome and waste cyanide storage tanks are installed below floor level. The final neutralizing basins (Slide 9) and the cyanide and chrome destruction tanks are installed so as to take advantage of gravity flow from the cyanide and chrome destruction tanks.

This slide shows the top of the final neutralizing basins, the cyanide and chrome destruction tanks, the Sodium Hypochlorite and the 10,000 gallon waste alkali storage tanks.

Local continuous ventilation is provided for all treatment tanks. The treatment area has general ventilation and air supply. This is mainly a saftely measure and if any one of these systems fails, an alarm is sounded on the central control panel.

The control and test room is located inside the waste treatment area (Slide 10). The slide shows the control room in the background and the cyanide destruction unit in the foreground. This room contains the central control panel, a load centre with stop-start buttons

and running lights for pumps, mixers and fans and also the laboratory equipment.

(Slide 11). This slide shows the control panel described earlier located inside the control room, pH and ORP controllers for the cyanide destruction are on the left. The controllers for the chrome destruction and the final neutralizing basins are on the right. In the centre is the alarm system panel, level indicators for the waste acid and alkali storage tanks and controls which allow the operator to divert the flow of wastes from the treatment tanks to the holding tanks and vice-versa.

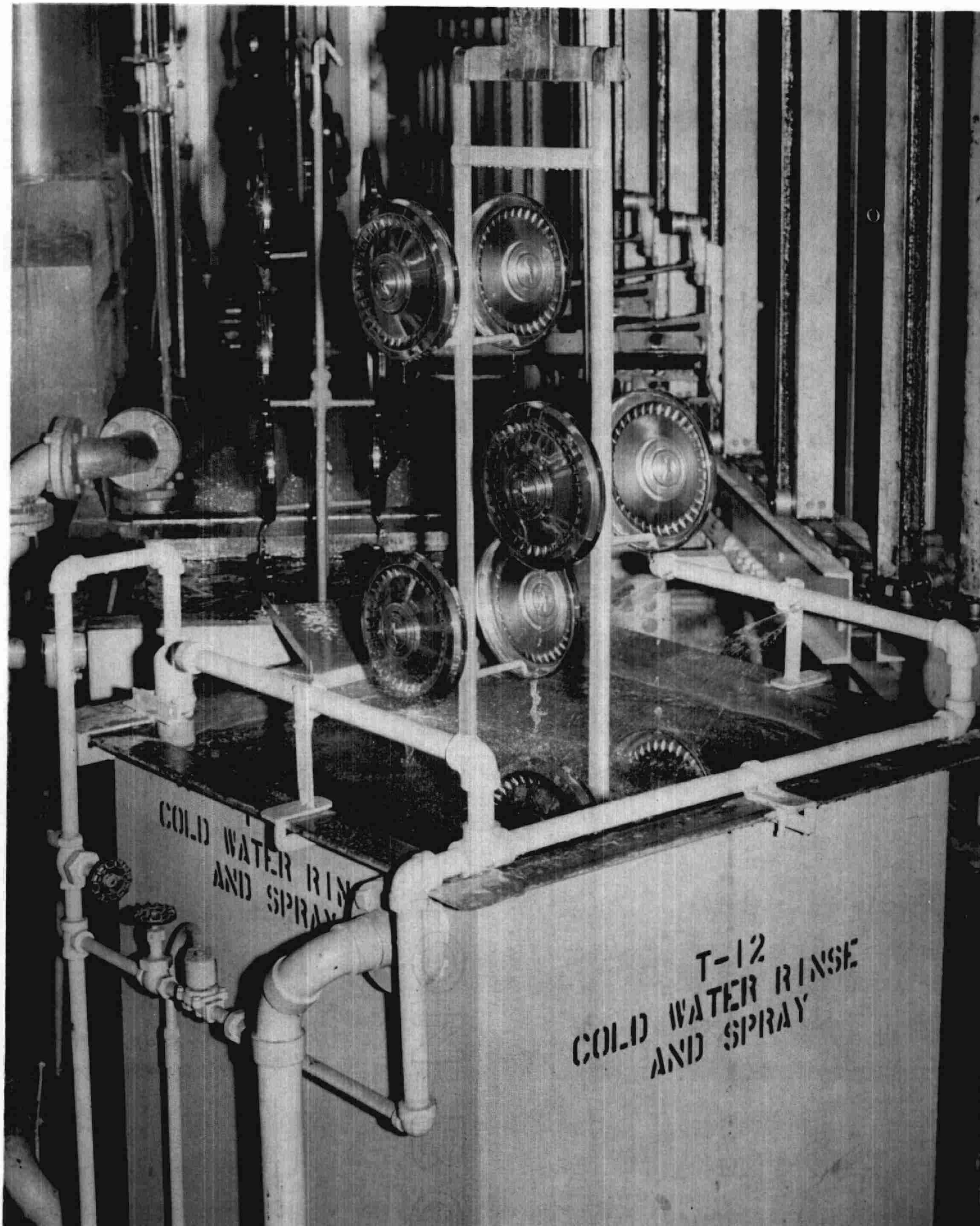
(Slide 12) shows part of the laboratory test section of the control room and the load centre.

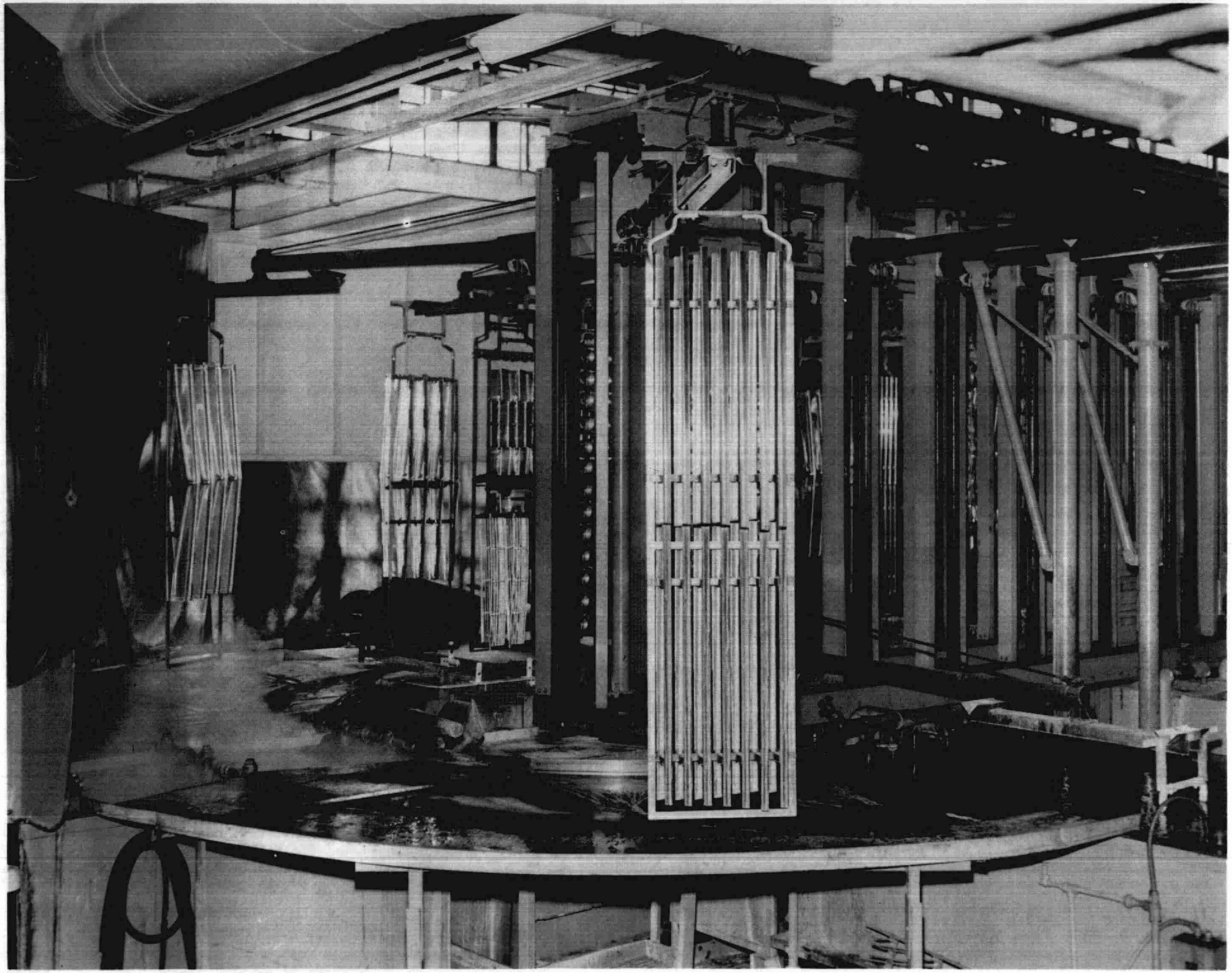
A detailed presentation of the chemical reactions involved in the action of the treatment chemicals on the plating wastes was not included in this paper. These are well-known and may be found in a number of publications. *

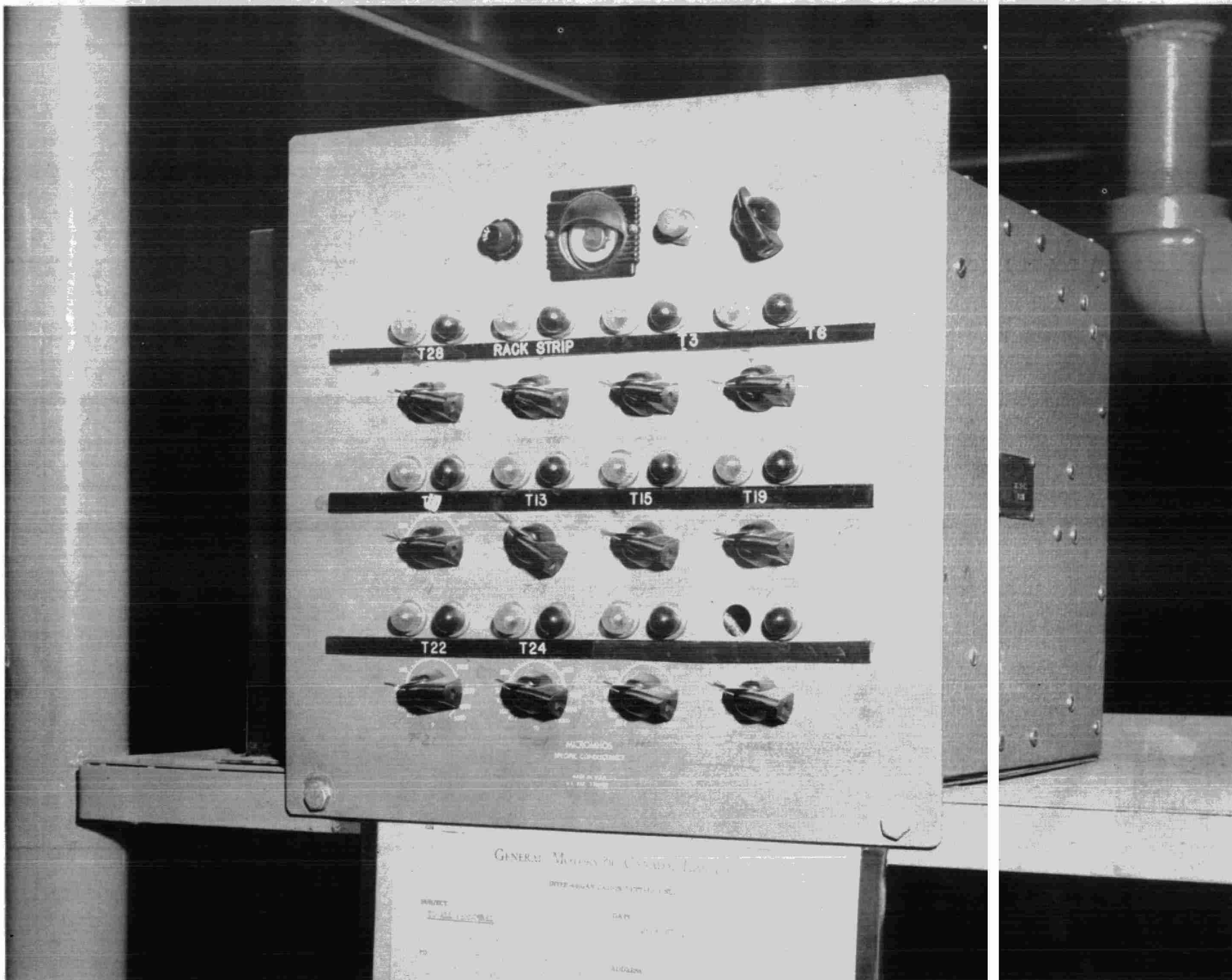
In the equipment where contact is made with acids, chrome wastes and Sodium Hypochlorite, saran-lined pipe and valves and PVC lines tanks are used. The remainder of the equipment is constructed of black iron except for the final neutralizing basins which are of reinforced concrete lined with mastic.

The plating waste treatment equipment has been in operation for about two years. After the initial start-up problems were overcome, we have found that this installation is operating efficiently.

* "Methods for Treating Metal Finishing Wastes" - published by - Ohio River Valley Water Sanitation Commission.


COLD WATER RIN
AND SPRAY
T-12
COLD WATER RINSE
AND SPRAY

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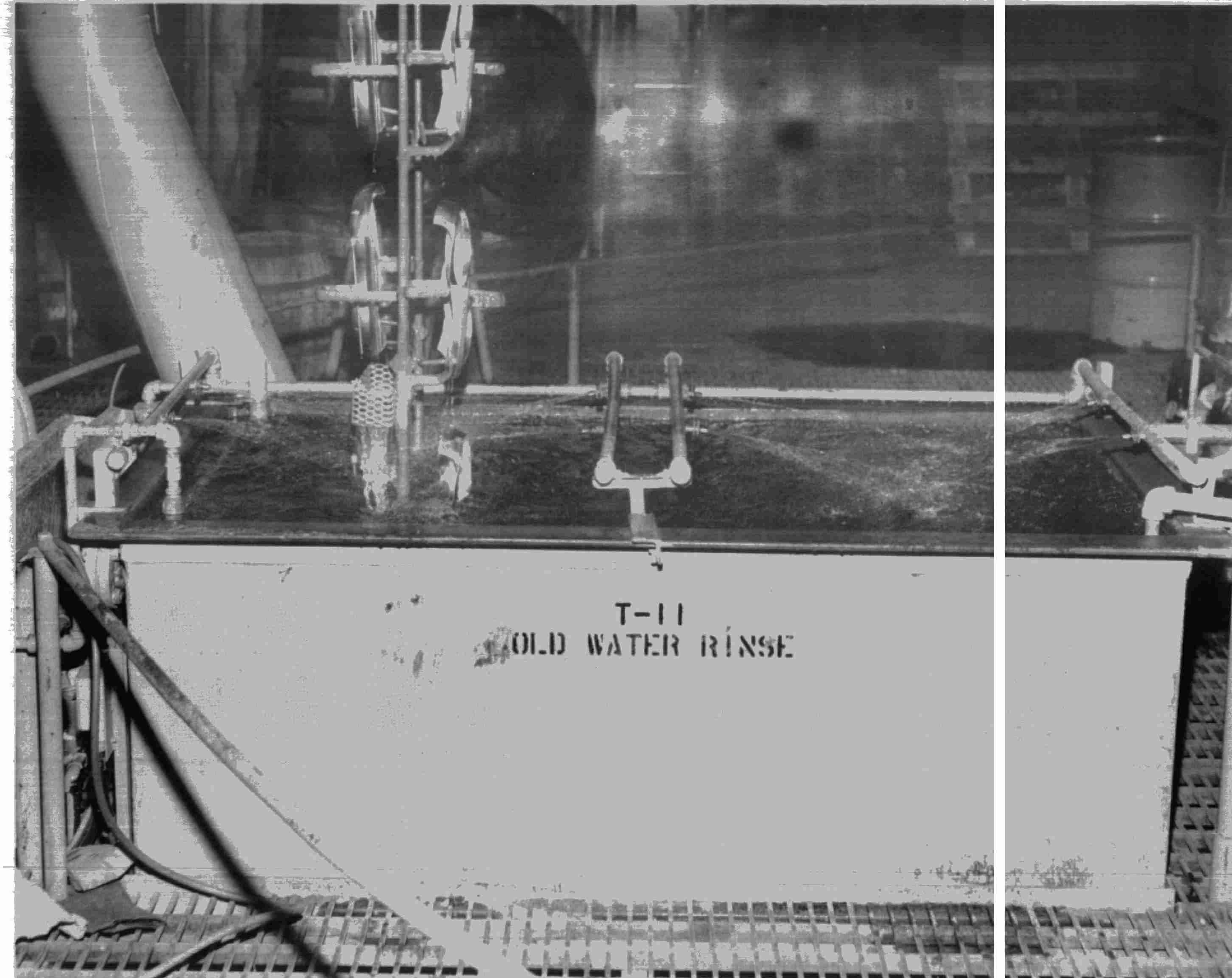
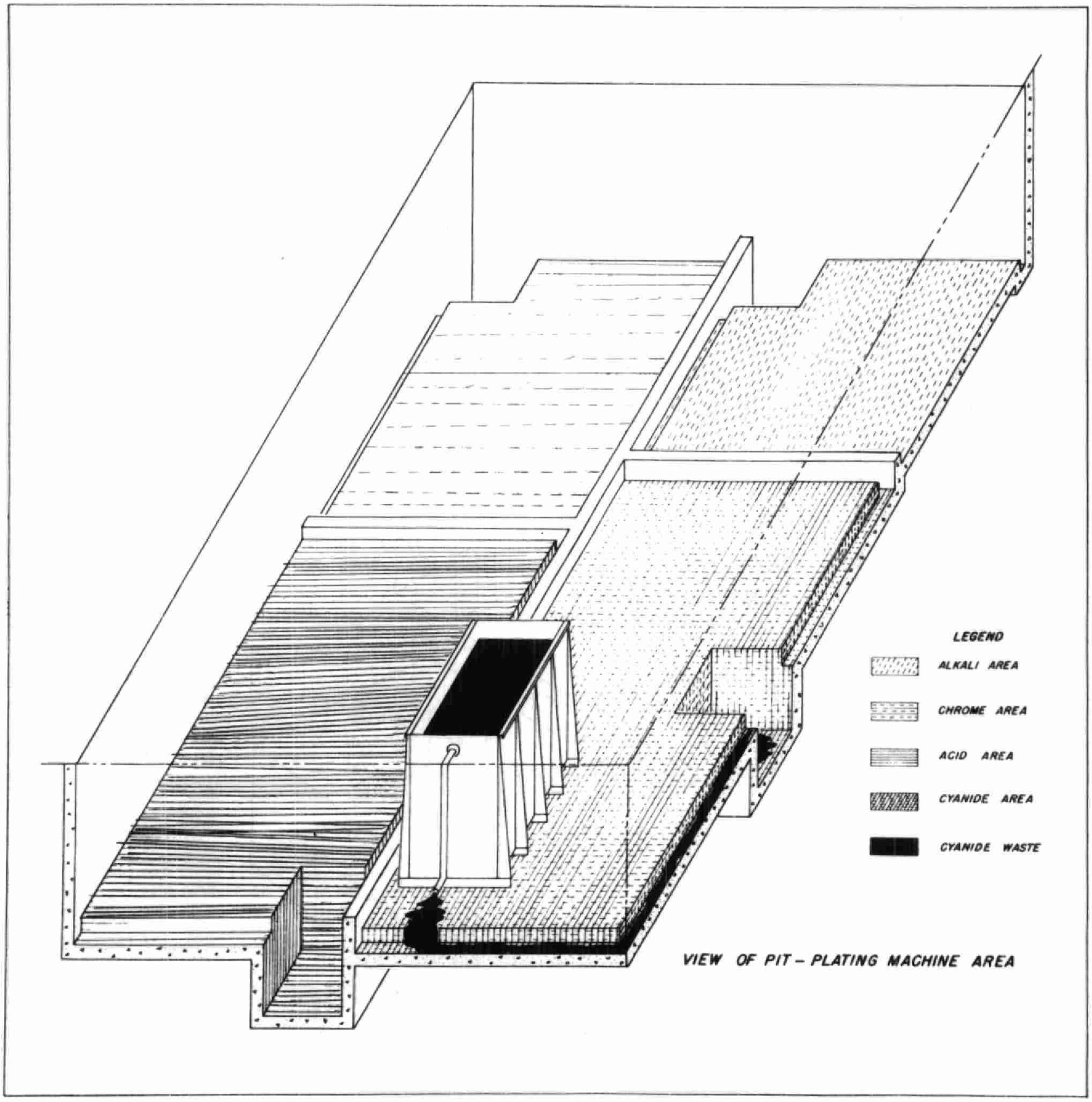
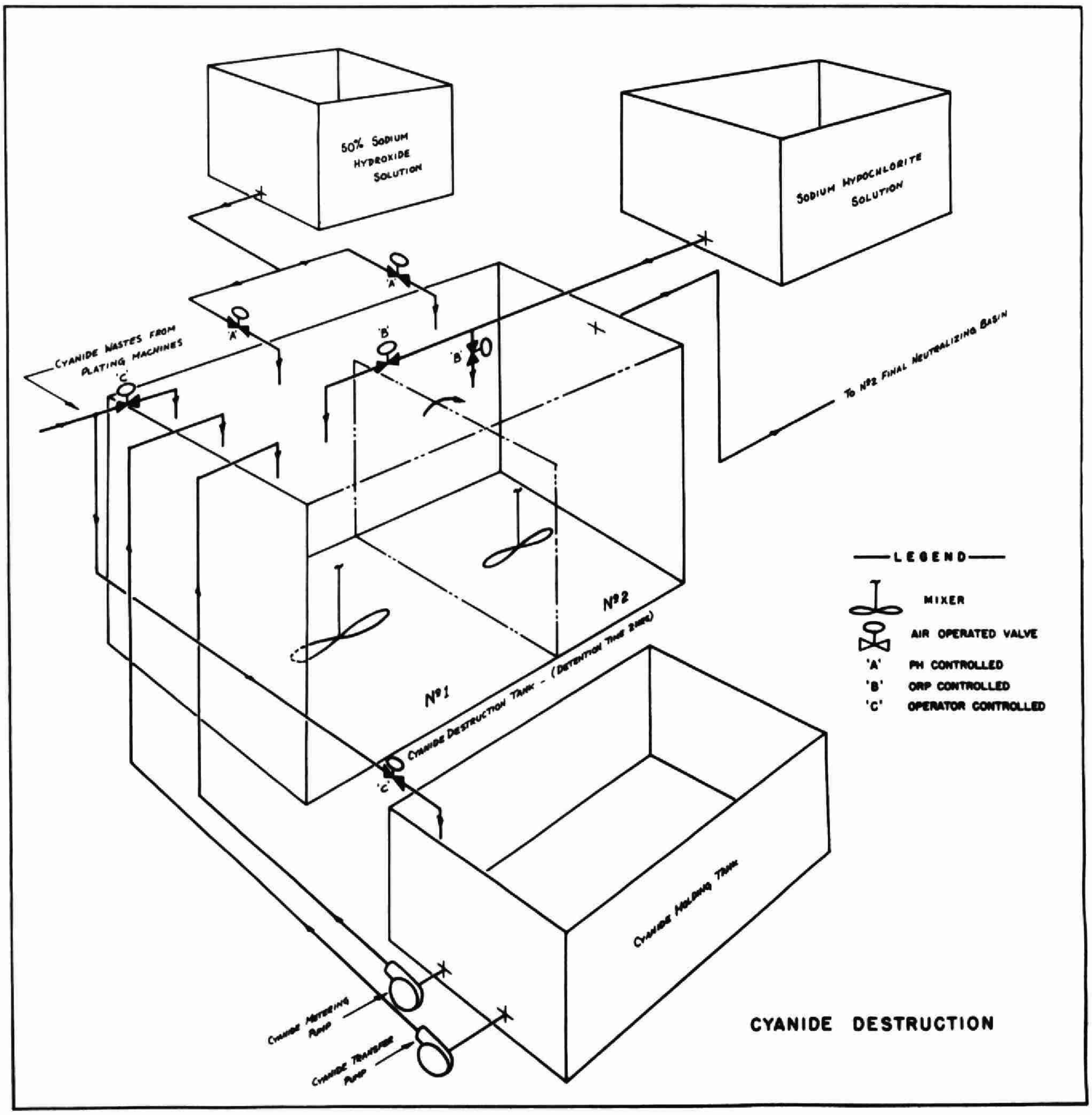
SPECIFIC CONDUCTANCE

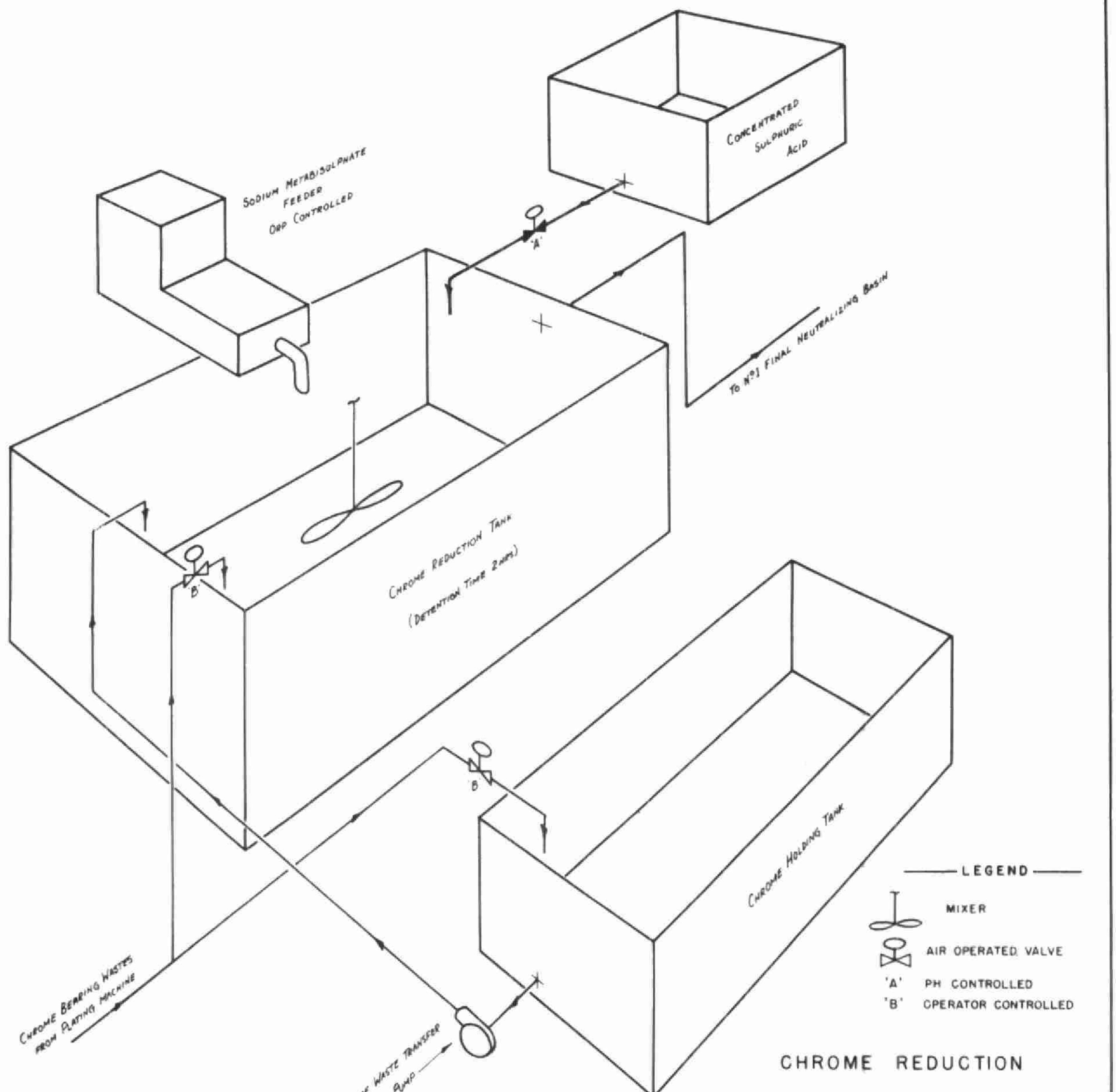

T-11
OLD WATER RINSE



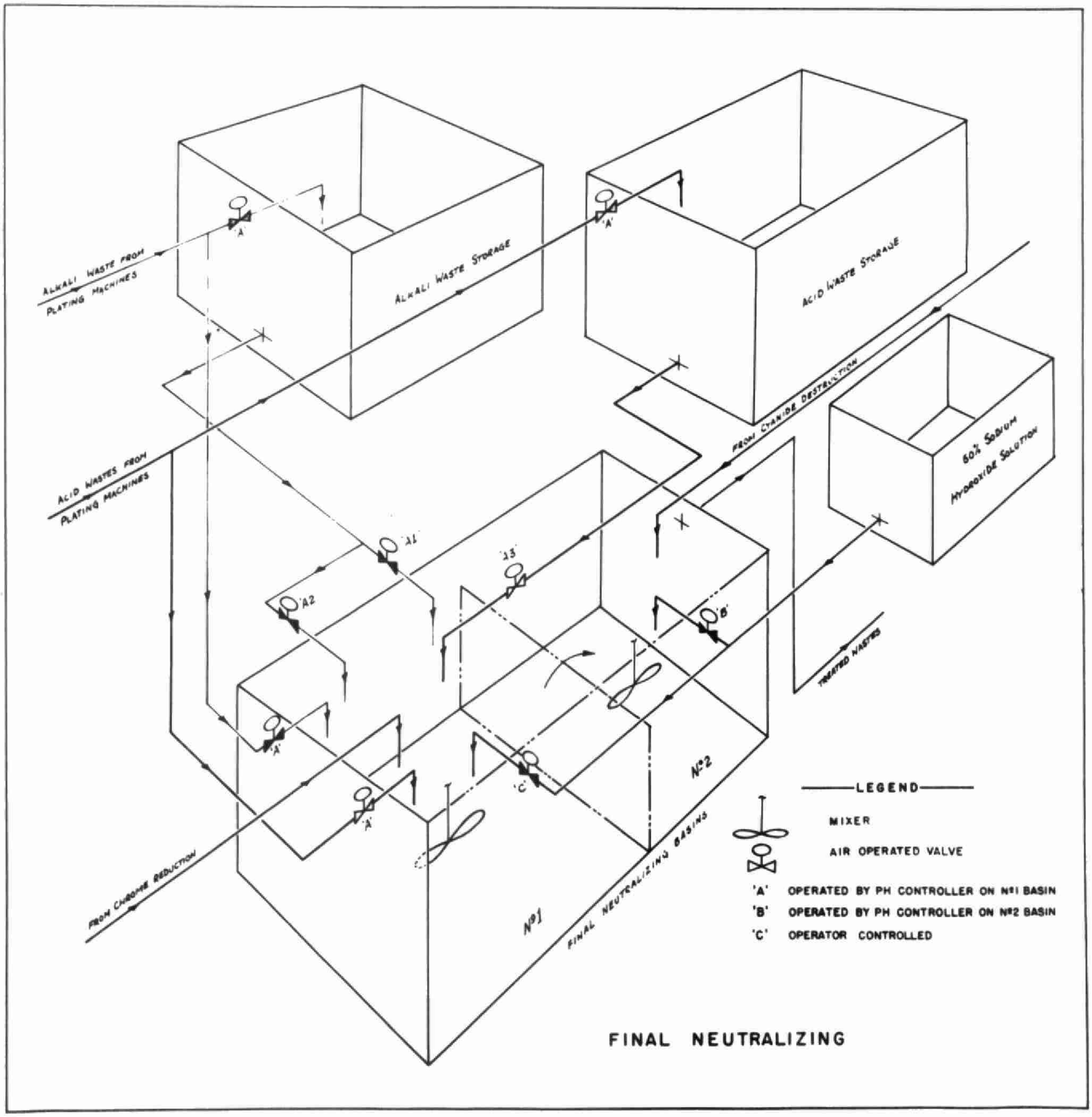
VIEW OF PIT – PLATING MACHINE AREA



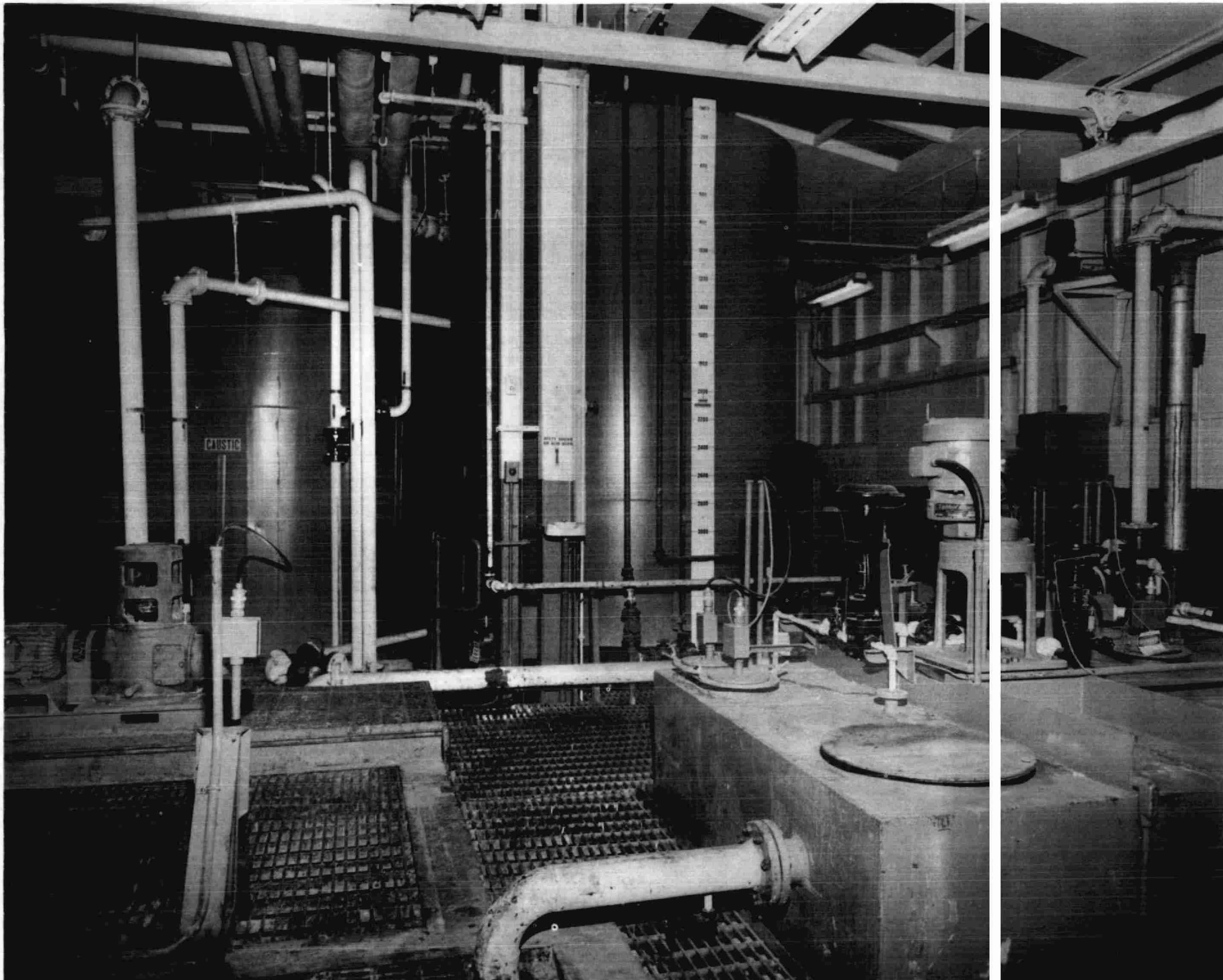
CYANIDE DESTRUCTION

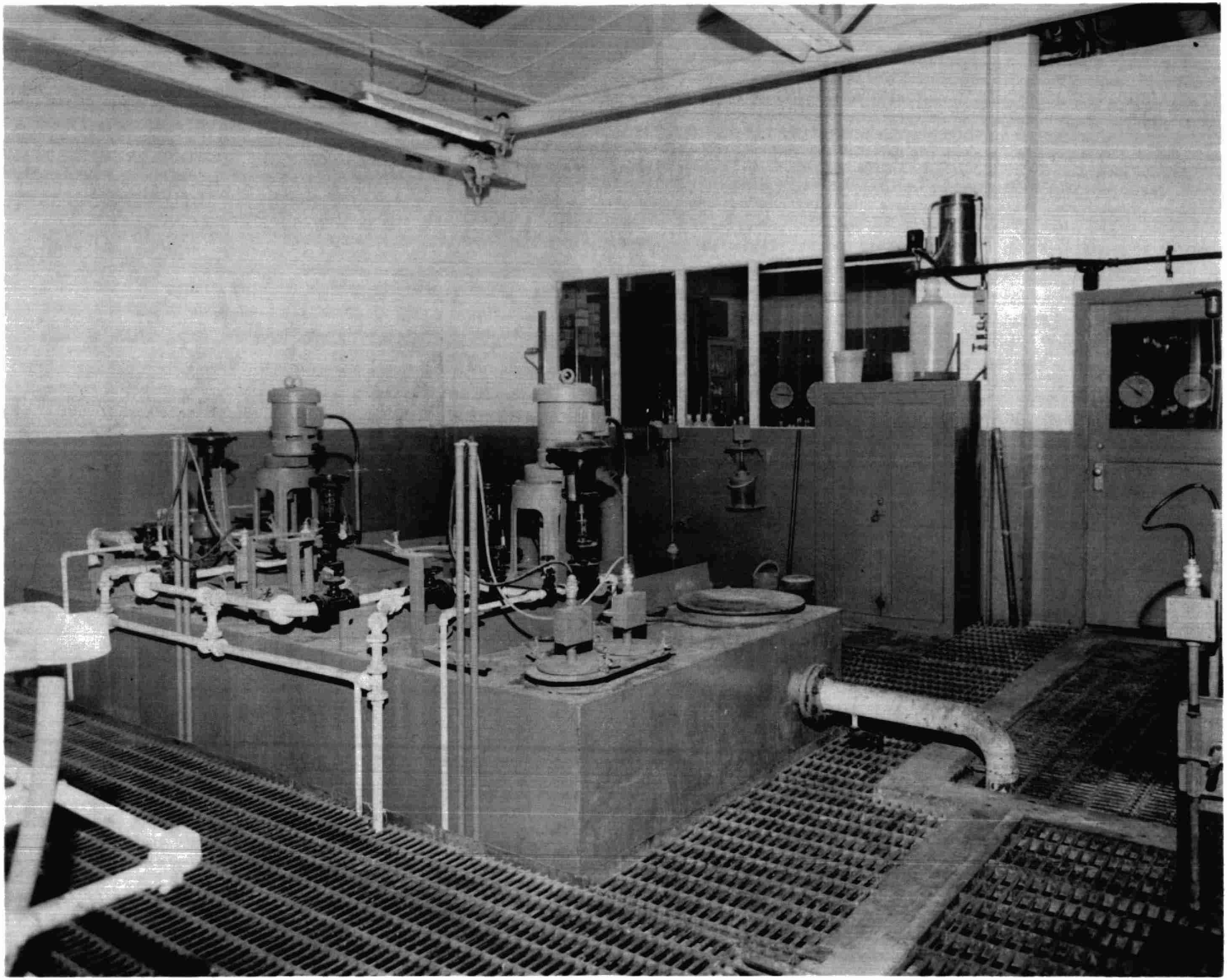


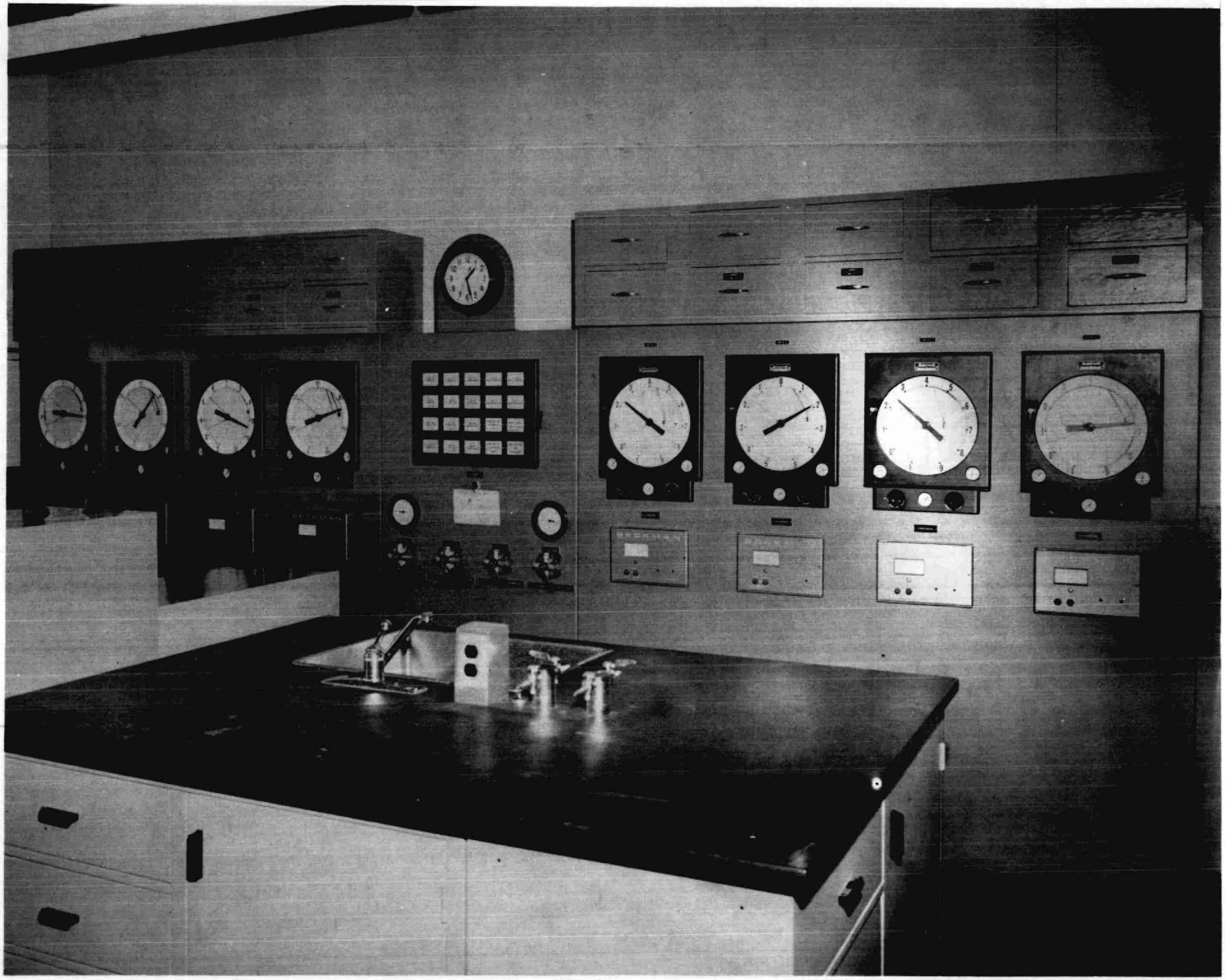
CHROME REDUCTION

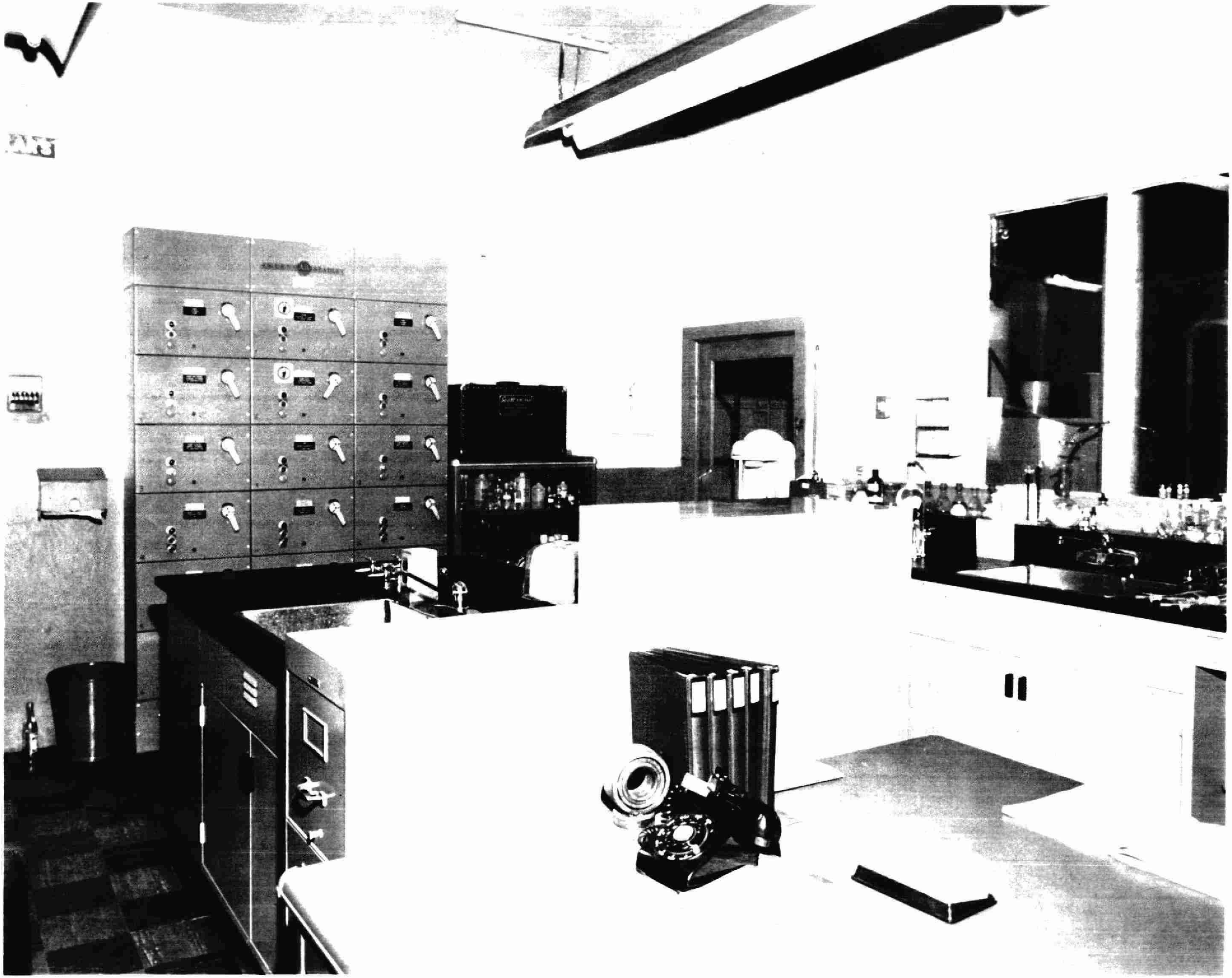


FINAL NEUTRALIZING


CAUSTIC







WASTE WATER TREATING FACILITIES AT ETHYL CORP. OF CANADA LIMITED.

by

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Ethyl Corporation of
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Corunna, Ontario.

This paper is a description of the waste water treating facilities at the Sarnia plant of Ethyl Corporation of Canada Limited. The plant manufactures tetraethyl lead, the basic ingredient in "Ethyl" antiknock compounds. The waste treating facilities are not unique; however, we believe that they are a good example of waste treatment in a chemical industry.

INTRODUCTION

Slide 1

The Ethyl Corporation of Canada Limited plant was built at Corunna (5 miles south of Sarnia) in 1956, and commenced operation in September 1956. It is the only manufacturing facility in Canada producing antiknock compounds for sale to oil refineries for blending with gasolines to improve octane ratings and, subsequently, for control of knock in the internal combustion engine.

Slide 2

The plant occupies 30 acres of a 100-acre site fronting on Highway 40 and the St. Clair River and immediately adjacent to the Canadian Oil Company's refinery.

Slide 3

The next slide shows the main building of the tetraethyl lead manufacturing area. The storage area in the foreground is for raw materials and finished product storage.

This photograph was taken looking north and the Canadian Oil Company's refinery can be seen in the background.

The main building is five stories in height and consists of four separate but connected operational areas. The tetraethyl lead reaction section is located at the front centre of the building. An area for handling liquid lead is at the right rear of this view and facilities for the manufacture of lead sodium alloy and finished product are located at the midsection of the building.

This building is serviced by a massive ventilation system which changes the air in the building as often as once per minute. The volume of air moved is considerable. Large ventilating supply and exhaust fans are located at ground and roof level. One of the supply fan houses can be seen at the lower left corner of the building. The exhaust stacks can be seen quite clearly and I will say more about the stacks later.

The total investment in the plant, including facilities for the manufacture of ethyl chloride and ethylene dichloride added in 1960, is just over twelve million dollars. Of this investment, one-half million dollars was spent on waste water treating facilities; however, total investment in overall waste control and hygienic facilities is considerably greater than this figure.

Slide 4

Tetraethyl lead is produced by the reaction of lead-sodium alloy with ethyl chloride.

Slide 5

Lead sodium alloy is made by alloying molten sodium and lead; the alloy is then solidified into a flake form and charged to autoclaves. The alloy is reacted, under controlled conditions, with ethyl chloride to form liquid tetraethyl lead.

The tetraethyl lead is stripped from the lead and salt formed in the reaction by steam distillation. The residual lead and salt are routed to a settling pit from which the dilute salt solution is routed to the process water purifiers. The residual lead is dried and recovered for recycling in the tetraethyl lead reaction.

The crude tetraethyl lead is purified and blended with ethylene dibromide and ethylene dichloride to form antiknock compounds.

Ethyl chloride and ethylene dichloride are produced in units completed in November of 1960. Ethyl chloride is manufactured by the reaction of anhydrous hydrogen chloride and ethylene in the presence of an aluminum chloride catalyst. Waste gas from this unit is scrubbed with water to remove hydrogen chloride which is then treated as a water waste.

Ethylene dichloride is made by reacting ethylene and chlorine.

Waste gas from this operation is also scrubbed with water to remove hydrogen chloride formed by side reactions.

Cooling water is used on a once-through basis in all three operations and is subsequently utilized as a pre-discharge diluent. The source of the cooling water is the St. Clair River, although this water and our steam requirements are purchased from Canadian Oil.

SOURCE AND TREATMENT OF WASTE

The background of the parent Ethyl Corporation in the United States was drawn on extensively in the design of the plant and the waste water treating units. The facilities at the Sarnia plant represent the most effective basic methods developed by Ethyl U.S. during 35 years of operation. Being relatively new, the units also incorporate the latest modifications and improvements developed by our parent organization.

The toxic nature of lead in any form is familiar to everyone, and we treat any water contacting lead as contaminated waste.

The greater bulk of the waste water originates in the steam distillation operation. Smaller quantities accumulate from the tetraethyl lead purification process, tank washing, and building and area washdown.

Water and finely divided granular lead from the steam stills are discharged to a large settling pit. From here, the water overflows to the process water purifier feed sump, from where it is pumped to the purifiers.

Slide 6

There are two process water purifiers; one in operation, the second one on standby.

The waste water purifiers are 22-foot diameter Infilco Accelator clarifiers designed to operate up to approximately 700 gpm flow rate. Each treater has two 45° concentrator zones equipped with a special gate developed by Infilco and Ethyl.

The acidifiers located in front of each treater reduce the concentrated slurry to a sludge which can be recycled to the settling pit for lead recovery. The acidifiers are five feet in diameter and mixing of the acid and slurry is done with propeller type agitators. The acidified water from these vessels is returned to the feed sump for pH control on the raw water.

These treaters and the acidifiers are in rotational service to assure maximum operating and maintenance efficiency.

Similarly, two pumps - one steam-driven, the second electrically-powered - are maintained in the feed sump.

Slide 7

The next slide shows the schematic flow of the process streams under treatment. Water overflows from the settling pit to the feed sump where sulfuric acid addition is controlled by pH monitoring. The feed water is pumped to the purifier and separated into a solid or sludge stream which is returned to the settling pit and a clarified effluent which overflows to the main plant sewer. Sludge which has been agglomerated with ferrous hydroxide floc formed by $FeSO_4$ addition and the pH control on the feed sump is collected in the concentrator zones of the purifiers and routed to the acidifier for floc breakdown by sulfuric acid addition. The acidified sludge is routed to the settling pit, the overflow is returned to the feed sump.

Level control on the treater feed sump controls the bypass valve on the raw water loop, sending more water to the treater in the event of a surge in the feed sump or level increases in the settling pit. pH monitoring of the feed sump controls the acid addition to maintain the pH of the raw water for optimum ferrous hydroxide floc formation. The flow control records the flow and also controls ferrous sulfate addition and concentrator draw-off by activation of the appropriate instruments. Sulfuric acid addition to the acidifiers is controlled by the concentrator draw-off instrument.

Draw-off from the acidifiers and from the bottom of the purifier are present on cycle times. pH is recorded for the acidifier and for the purifier effluent.

Raw water is introduced into the primary mixing zone under the treater baffle. $FeSO_4$ chemical is also introduced into this zone and, since the pH is controlled, gelatineous $Fe(OH)_3$ floc is formed and attaches to the solid particles, particularly lead, from the raw water stream.

A rotor impeller located in the central draft tube portion of the treater supplies a pumping action which circulates the floc and raw water up through the central draft tube portion, over the top of a concentric baffle and down the outside of the draft tube. Most of the stream is circulated back under the lower lip of the baffle into the mixing zone.

The heavier floc and lead particles which are forced over the baffle are carried by their own momentum to the bottom of the treater where they form a slurry pool and are recycled. Fresh, clean water is not carried into the slurry pool but escapes and is discharged out the top of the treater as clarified water.

25% of the outer portion of the water treaters is closed off at the bottom to form the concentrator zones to prevent circulation at this point and to collect slurry for discharge. Slurry which is collected in these concentrators is drawn off and acidified for recovery of the lead.

Draw-off from the bottom of the treater prevents sludge build-up which would hinder proper recirculation.

The draft tube or floc zone is continuously sampled for visual inspection and control analysis. The effluent from the purifier is also sampled continuously for visual inspection and spot sampling for lead analysis. These two sample streams run to a booth located in front of the purifiers.

The effluent overflows from the treaters and is diluted ten times by cooling water from the plant and this combined plant effluent is sampled continuously.

Slide 8

The sampler is set to collect one gallon per day. This sample is analyzed daily for lead and an aliquot composited for complete analysis.

ANALYTICAL DETAIL:

The lead content of the process water treaters and the plant effluent is understandably our control analysis. Salinity is second in importance and is closely monitored. Spot samples are taken every shift on the raw water and the treater effluent. The former sample is composited for operating efficiency data. The treater effluent sample is analyzed for lead and an aliquot of this sample is composited

The composite samples of raw water, treater effluent and plant effluent are analyzed monthly. The monthly term on these samples was adopted only recently after five years' experience on a weekly term.

Slide 9

The following tables shows typical analyses of the three composite samples collected for waste water control. A typical analysis of St. Clair River water is shown for comparison. The units for this data are p.p.m. except for the pH.

Waste Water Analyses
All in ppm except pH

	pH	Chlorides	Suspended Solids	Total Lead
Inlet Water	7.8	10	10-15	-
Plant Effluent	8.3	928	20	1.7
Water Treater Effluent	10.4	10,000	30	5.5
Untreated Water	10.8	10,000	125	45.0

EtCl-EDC Plant

Treatment of the acid waste gases from the ethyl chloride and

ethylene dichloride units consists of scrubbing the gas in venturi-type scrubbers to dissolve free hydrogen chloride which is then neutralized in a limestone neutralizing pit.

Slide 10

The venturi-type scrubbers are made of Haveg material to eliminate the potential corrosion problem and operate in a cascade-type arrangement. The primary zone of the fume scrubber pit is fed by two scrubbers. Gases from the primary zone are scrubbed through a second scrubber before venting to the atmosphere. The water from the primary zone flows under a baffle to the secondary zone and under a second baffle to the neutralization pit feed line.

The inlet to the neutralization pit is located in the diagonally opposite corner of the pit from the outfall to force the acid water to percolate up and across the limestone bed.

The pit is 6 feet wide, 12 feet long and 10 feet deep and is charged with 15 cubic yards of crushed limestone to obtain a bed depth of 5 feet. The limestone is 3/4" to $1\frac{1}{2}$" in size and the flow through the pit is about 60 gpm at a hydrochloric acid concentration of 0.07 weight percent.

The effluent from the neutralization pit is monitored on a shift basis for pH and the chloride content is checked on a weekly composite sample.

Initial experience with the pit indicates that it is effectively neutralizing the waste; however, we do not have sufficient data or experience to say more at this time.

The neutralization pit effluent and cooling water from the ethyl chloride and EDC units are combined and routed to the main plant sewer.

The main plant effluent is discharged to the St. Clair River through a corrugated steel pipe, 5 feet in diameter, trenched into the river bottom. The outlet of this line is at the bank of the shipping channel. This installation was suggested by the Ontario Water Resources Commission as a means to provide better mixing and dilution of the effluent with the receiving water.

This method of effluent disposal is very effective. A river water survey conducted in 1958 indicated that no lead was detectable in the water downstream of the outfall.

Slide 11

AIR POLLUTION CONTROL

The one source of air pollution which occupies our attention is the lead recovery area stack. To minimize the discharge of lead dust, lead oxides and other lead compounds, the exhaust gases from the furnace are pulled under vacuum through a Pease-Anthony water scrubber. The water discharge from the scrubber is routed back to

the lead settling basin for reclamation of the lead dust and a clean gas discharge is vented through a separate stack. Here again, provision has been made for equipment failure. A complete spare fan and spray pipe are held in readiness in event of malfunction.

Prior to plant construction, models of the plant were subjected to wind tunnel tests to determine the area surrounding the plant which might be affected by discharge from the various building stacks. Stack heights are sized to prevent any possible pollution in the residential area immediately west of the plant. Air surveys in this residential area and in an extensive area around the plant have shown no evidence of airborne lead pollution of the area.

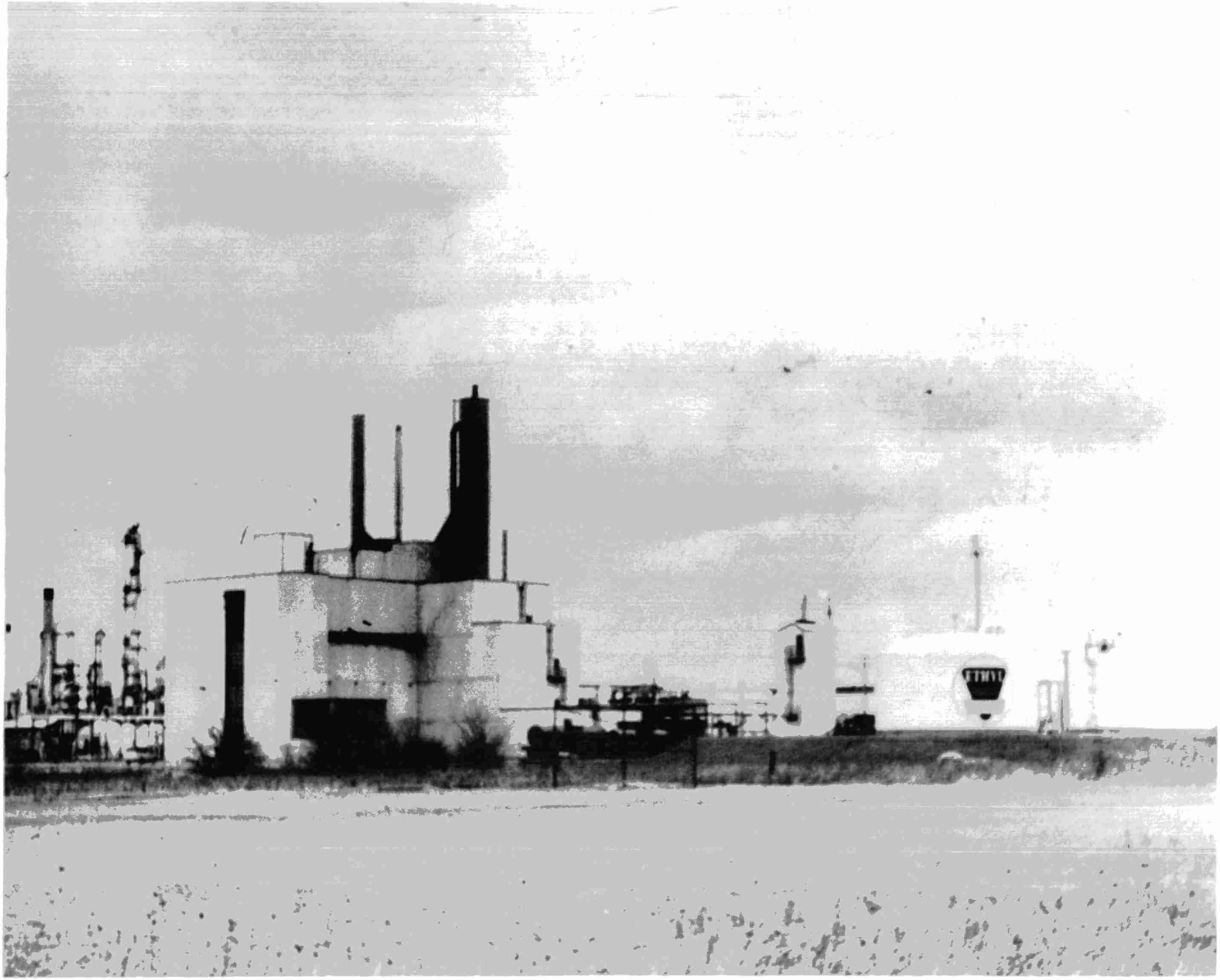
CONCLUSION

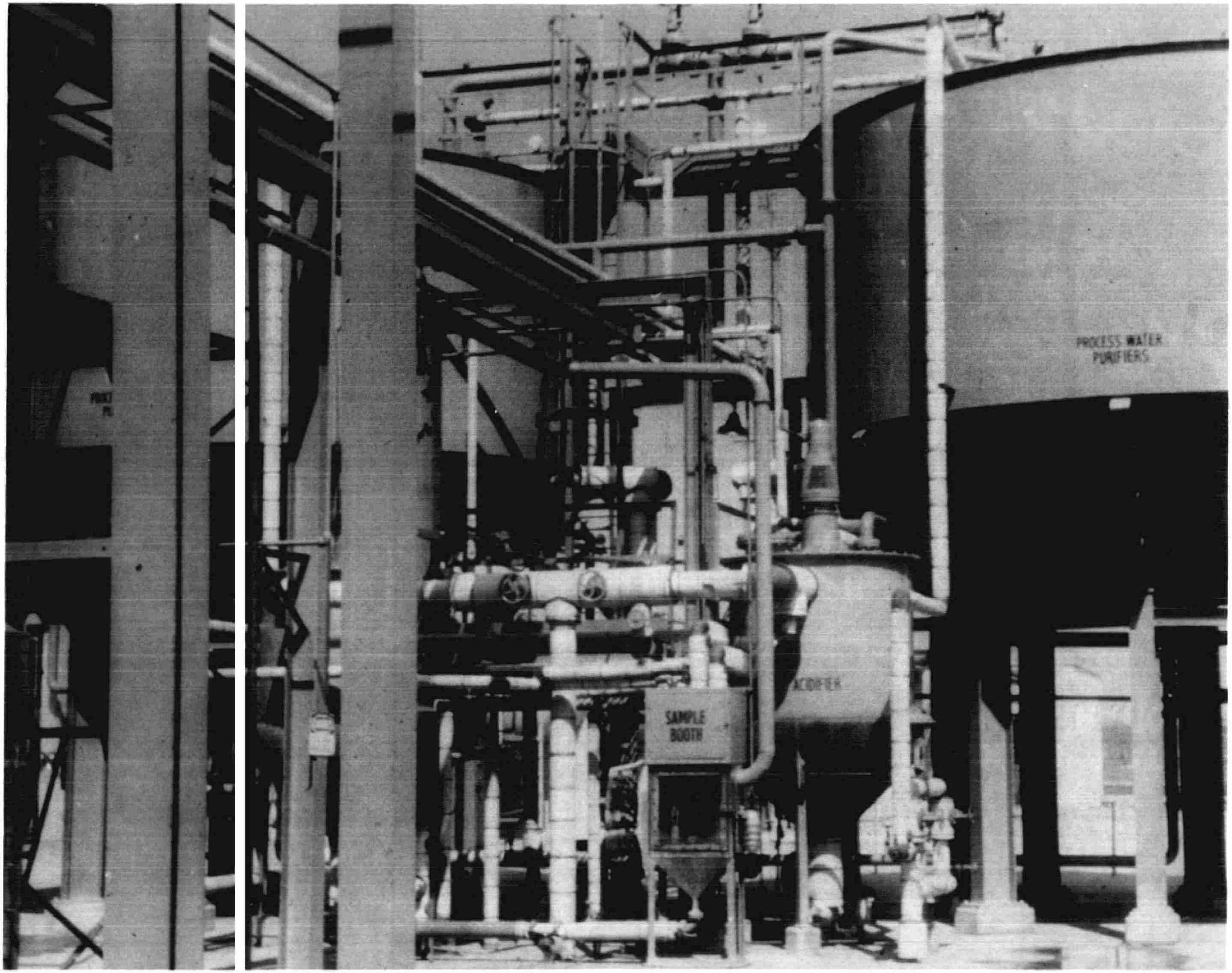
Ethyl of Canada has made every effort in all phases of planning, construction and operation to be a good neighbour. We have sought Ontario Water Resources Commission approval at the design stage of our installations and followed their recommendations. Ethyl is a member of the well-known St. Clair River Research Committee and, as such, we have cooperated with our industrial neighbours fully. On our own initiative, we have conducted air and water pollution surveys to assure ourselves that our treatment methods are as effective as possible.

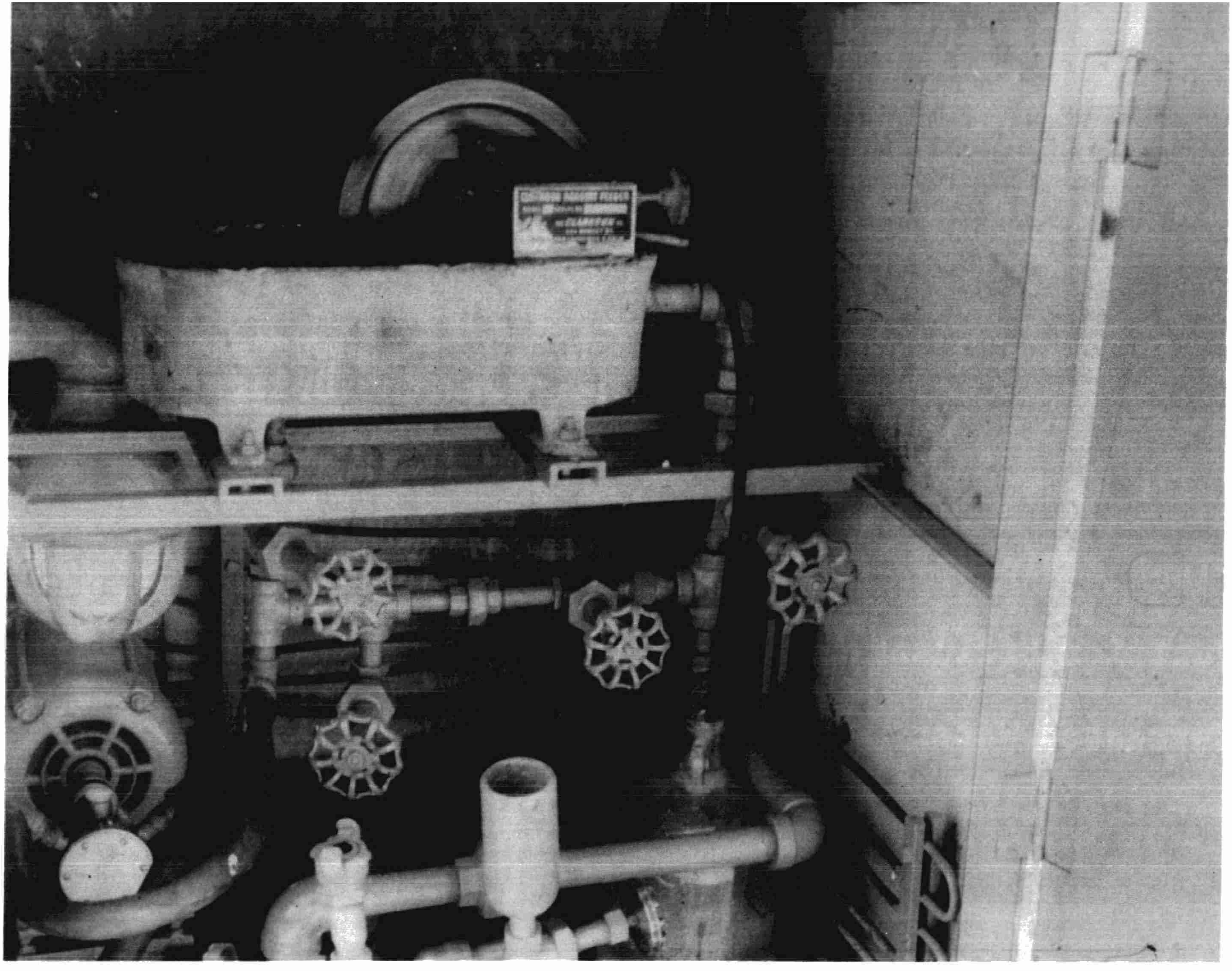
We continue, through inter-plant correspondence, to keep abreast of waste treatment improvements at Ethyl U.S. plants.

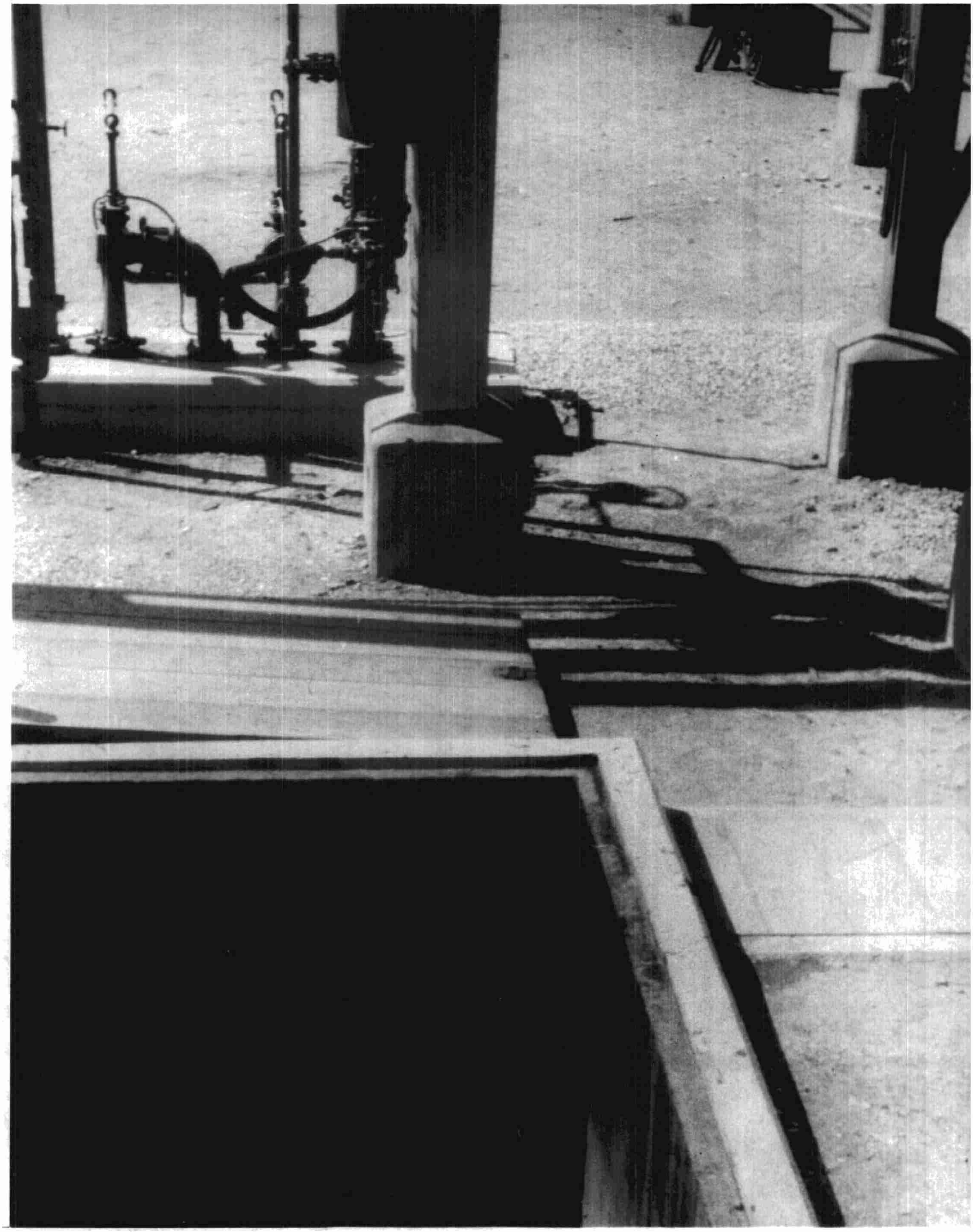
Although this paper is more general than those normally presented at this conference, it is an example of waste control in tetraethyl lead manufacture. As such, we hope it has been of interest.

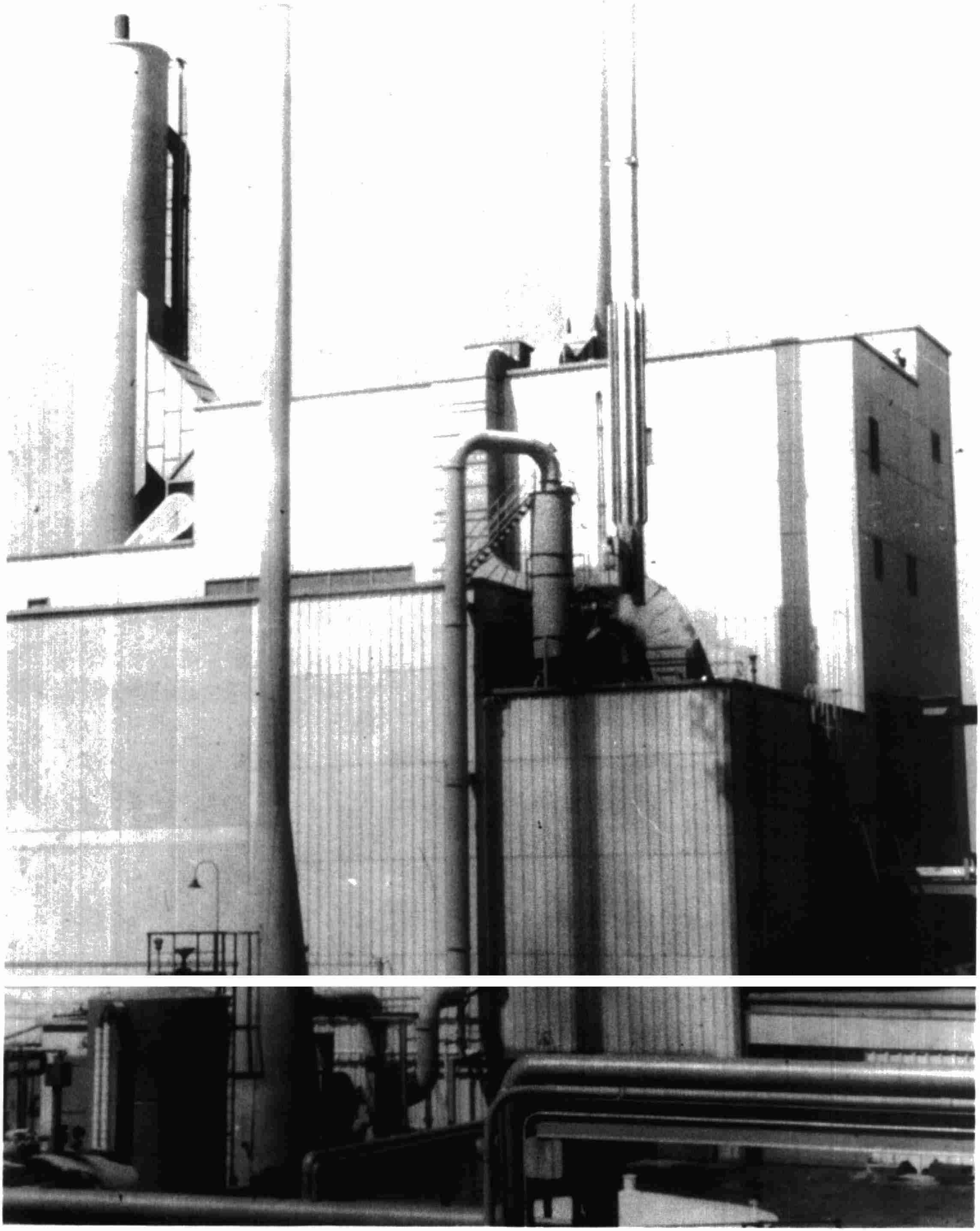

'ETHYL'
ANTIKNOCK
COMPOUND
ETHYL CORPORATION
OF CANADA LIMITED
ETHYL CORPORATION
OF CANADA LIMITED




PROCESS WATER PURIFIERS
ACIDIFIER
SAMPLE BOOTH

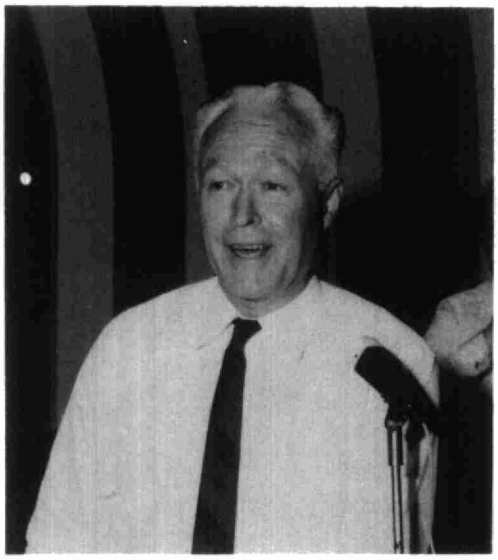







Georgian Bay
ROOM

INDUSTRIAL EFFLUENTS AND UNITED STATES-CANADA BOUNDARY WATER QUALITY MANAGEMENT.



by

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Washington, D.C.

INTRODUCTION

Waters flowing across or along the boundary between Canada and the United States are our common heritage and vital to the interests of both countries. The many uses which these waters now serve make it imperative that nothing shall jeopardise this important international asset. The waters are utilized, among other things, for domestic and industrial water supplies, sanitation purposes, shipping and commerce, recreation, power and drainage. The following discussion is concerned with developments, giving particular attention to industrial effluent considerations, in international boundary water quality management for mutual benefit of the two countries now and in the future.

While considerations discussed apply in general to all boundary waters, the aim herein is to give major attention to the waters of the Great Lakes and connecting channels, the Rainy River and Lake of the Woods.

BOUNDARY WATERS TREATY

The concern about pollution in these boundary waters is

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revealed in a treaty entered into by the United States and Great Britain in 1909. This treaty stipulated, in Article IV, that boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other side. Provision is also made, under Article VII, for establishing and maintaining an International Joint Commission of six members. Provision is made for submitting to the Commission any problem concerning the rights or interests of either country along the common frontier. This procedure involved investigation and report on matters referred to the Commission by the governments of Canada and the United States. The value of the Commission throughout the intervening years has been recognized worldwide as an admirable method for settling the numerous problems which are to be expected with such an extensive border.

POLLUTION INVESTIGATIONS

Pollution of the boundary waters has been a continuing problem for many years. It resulted in a Reference from the two Governments to the International Joint Commission and an investigation in 1913. At that time the entire boundary waters were studied. The report of the Commission was later presented to the two countries. It contained recommendations for remedial measures, but the outbreak of World War I and later events adversely affected action on these charges.

No further investigation was undertaken by the International Joint Commission until 1946. At this later time the extent of the boundary to be studied was reduced, but the scope and intensity of the investigation was widened. This was the result of the changes which had taken place in the intervening years between examinations of these waters.

The Reference on pollution in boundary waters made to the Commission April 1, 1946, concerned sewage and industrial wastes emptied into the waters of the St. Clair River, Lake St. Clair and the Detroit River. The Commission was asked to study all phases of pollution which might detrimentally affect the other side of the boundary, and to report to the Governments on remedial measures and costs involved in abatement of pollution of these boundary waters.

The 1946 Reference was extended later on two occasions to include first, the St. Marys River, and secondly, the Niagara River. The task was to make thorough studies of these sections of the boundary waters and set forth facts essential in developing a program for pollution abatement.

One of the initial steps by the Commission, in meeting the terms of Reference, was the appointment of a Board of Technical Advisers. This action was taken on May 15, 1946, when a Board of eight engineers was selected. Four of these were from the United States and four from Canada. The selection included two from the Federal service of each country, and two from the State or Provincial service bordering on the waters in question. A similar Board was created for the Niagara frontier when the Reference was extended on April 2, 1948, with two representatives being designated for the

State of New York.

In keeping with the requests of the two governments, the International Joint Commission conducted comprehensive surveys of these boundary waters and principal pollution sources during the period 1946 until 1950. This work in the United States was performed by the U.S. Public Health Service under the general direction of the Board of Technical Advisers. The report on these studies entitled, "Report of the International Joint Commission, United States and Canada, on the Pollution of Boundary Waters", published in 1951, was accepted by both governments.

An outgrowth of the above-mentioned studies was the adoption by the International Joint Commission of "Objectives for Boundary Waters Quality Control". These objectives are set forth in detail in the 1951 report.

Mention should be made here of a similar Reference to the Commission in 1959 on pollution of Rainy River and Lake of the Woods. The same procedure described above has been followed, with establishment of an Advisory Board composed of two representatives each from both Federal Governments, from the Province of Ontario, and the State of Minnesota. This Board initiated boundary water quality studies in 1960. The work, now in progress, is concerned with ascertaining trans-boundary movement and effects of pollution by municipal sewage, and industrial wastes - mainly pulp and paper mill effluents.

POLLUTION CONTROL ADVISORY BOARDS

Early in 1952, the Commission appointed Advisory Boards on Control of Pollution of Boundary Waters for the Great Lakes' areas under Reference. These Advisory Boards like the two Technical Boards they succeeded, are made up of eight engineers representing the two governments, the States of Michigan and New York, and the Province of Ontario. One function of the Advisory Boards is to critically examine industrial waste problems and pollution abatement programs directed toward compliance with the objectives and to evaluate and interpret progress for the International Joint Commission.

The intensive studies initially undertaken required a large amount of field work. All of the above-mentioned agencies furnished personnel and cooperated in many ways in carrying out the boundary water pollution surveys.

CURRENT ACTIVITIES.

The United States' role in the continuing field activities since 1952,under guidance of the Advisory Boards, is being carried out with the aid of the Public Health Service. In close collaboration with the States, it maintains field units in Detroit and Buffalo for the U.S. Section; and the National and Provincial Health Agencies provide field services for the Canadian Section; of the Commission. The field activities include collection of basic water quality data, studies of trans-boundary travel of pollution, determination of improvements effected by municipal

and industrial waste treatment, assembly of data on water uses, application of new analytical techniques (carbon filter, bioassay, etc.) in boundary water pollution control investigations, and other such work involved in providing information to assist the International Joint Commission in carrying out its functions relating to boundary water quality.

The International Joint Commission and its Advisory Boards meet periodically to review progress being made, to indicate where needs exist for putting remedial measures in effect for control of pollution, and to see that such findings are brought to the attention of the appropriate enforcement agency. The Commission is performing an important role in stimulating the installation of sewage and industrial waste treatment works and other improvements to abate pollution of the boundary waters. An international system for warning downstream water users following industrial waste spills has been established. Cooperative working relations are maintained with State and Provincial water regulatory agencies.

In addition to municipal sewage treatment problems, many of which involve disposal of wastes from manufacturing plants, there are a wide variety of industrial effluents entering the boundary waters. The wastes are from such industries as pulp and paper, synthetic organic chemicals, electro-chemical, petroleum refining, automobile, iron and steel, by-product coke, synthetic fiber, petro-chemical, rubber, electrometallurgical, textile and many others.

Larger industries have, for the most part, elected to solve their waste problems independently through process control and separate waste treatment systems. The character and volume of wastes have dictated this approach in several cases and in others municipal sewers have not been accessible. Profitable by-product recovery has solved some waste problems. Descriptions of the various methods employed by industry to curb pollution would require a series of technical papers and is beyond the scope of this discussion. Because of the importance, however, of industrial effluents in boundary water quality improvement some of the trends are indicated.

ROLE OF INDUSTRY

Industry is increasingly demonstrating its recognition of the basic role it is being called upon to assume in the over-all program being developed largely through co-operative procedures - with industry working with Government in meeting mutual obligations and responsibilities. Methods vary with local circumstances, but the aim is to abate pollution by practical and effective means.

Mention has been made of effluents from pulp and paper mills. Considerable reductions in wastes from these mills have been brought about by in-plant process, equipment, and water flow control improvements, further implemented by internal 'housekeeping' methods. Not only do these methods reclaim or reduce wastes, but they cut down on waste water treatment problems.

The National Technical Task Committee on Industrial Wastes (U.S.), in collaboration with the National Association of Manufacturers, the

Chamber of Commerce of the United States, and the Conservation Foundation, has been acquiring the basic facts to bring up-to-date the information on industrial water use in the United States. This current study includes facts on recycling of waters employed in manufacturing processes where practicable to decrease needs for fresh water, as well as provide for taking care of waste water problems.

Some interesting figures are being developed by industry. For instance, the National Council for Stream Improvement of the Pulp, Paper and Paperboard Industries, Inc., in a progress report states as follows:

"The accomplishments of the pulp and paper industry's pollution abatement activities can be measured by several criteria; reduction in total waste load; reduction in pollution load per ton of product; conservation of fiber which can be translated into wood conservation, and conservation of water.

"In all of these, the industry has made notable, in fact phenomenal, progress. In the sixteen years between 1943 and 1959, annual production of paper and paperboard soared from 17,000,000 to 34,000,000 tons, an increase of 100%. The total waste load, on the other hand, was reduced by approximately 2%. To put it another way, the waste load from the average ton of paper and paperboard has been reduced by 51% since 1943.

"During this same period, the industry reduced its average fibre loss from 5% to less than 2%, a saving of over a million tons of fibre and a vast reduction in the waste load. From the conservation viewpoint, this saving is significant, representing as it does over one and a half million cords of pulpwood.

"This reduction in the pollutional effect of paper industry wastes was accomplished by a number of different methods. These include effluent treatment, new or novel waste disposal procedures, reduction of solids losses by recirculation of process waters and use of solids removal equipment, retention of increased percentages of wood substances in the finished product, more efficient recovery of chemicals and heat from spent pulping liquors, new recovery systems applicable to certain pulping liquors, and recovery of by-products".

Process and equipment improvements have resulted in a definite trend downwards in the volume and strength of pulp and paper mill effluents. The strength of the wastes on an oxygen demand basis has been decreased to as little as one-tenth their original strength by such improvements, with attendant reductions in chemical requirements, and other gains. Monitoring equipment is proving of value in avoiding occasional increases in sewer losses. The work on waste reduction is nearing an irreducible minimum, however, and further reductions necessitate consideration of treatment and disposal methods.

Certain pulp and paper mills, food processing, and various other types of plants with organic effluents in the boundary water area have provided oxidation ponds or waste stabilization basins, or have utilized spray irrigation systems for their waste waters. These developments are in keeping with the world-wide trend toward more fully utilizing nature's processes for economic treatment and disposal of liquid wastes.

The chemical industry, prominent among industries located in the Great Lakes Basin, is devoting steadily expanding efforts in the solution of its waste water problems. It was reported at the National Water Pollution Conference held in Washington during December 1960, that the industry "... has been outstanding in its program of water pollution control. In the past year alone, more than one hundred million dollars has been spent by the chemical industry of the United States on water pollution control". These expenditures include a number of improvements affecting the quality of boundary waters.

Throughout the Conference it was repeatedly stressed that water pollution accompanying urbanization and industrialization has reached such proportions that it is the number one problem of water supply in the United States. The inevitable fact emphasized was that we all cannot continue to enjoy the luxury of using water only once and discarding it. It was aptly stated that "everybody can't live upstream".

Safeguarding our water supplies by adequate sewage treatment, 'building out' or treating water-carried wastes of industry, augmenting low flows, and providing for reuse of water resources are fundamental to what has been termed water quality management.

WATER QUALITY MANAGEMENT

Pollution control is achieved by managing water quality to ensure the usability of water. Broadly stated, the objective is to secure and maintain available waters in such physical, chemical and biological condition that they will not create a nuisance or be harmful, detrimental, or injurious to the public health, safety or welfare, or to domestic, industrial, commercial, agricultural, recreational, or other legitimate uses, or to livestock, wild animals, birds, fish or aquatic life.

The basic concept - increased usability - in water quality management is not new. It has been the key to successful water pollution control programs in the past, and now simply needs wider application with the exercise of intelligence and common sense.

In developing water resources to meet continually increasing needs, attention was originally centred upon quantity only - the most water possible at lowest cost. Quality was assumed. The assumption was justified at the time. It was not realized how quickly municipal and industrial waste from an exploding population and expanding economy would degrade water quality, impairing its usability.

Looking at usability in realizing fully the potentials for

multi-purpose developments in the future, let's consider what is involved in water quality management. It has been described as a profession, an art, and a science - a profession because of certain known facts and principles that have been developed and advocated by predecessors in the various fields of water pollution control; an art because it requires the interweaving and application of certain specific technical, legal, and political skills; a science because there is a great accumulation of knowledge, facts and phenomena which is accessible and which has resulted in established principles to guide its basic activities.

GENERAL PRINCIPLES

The primary goal of water quality management is the provision of water of adequate quality as well as quantity to fill all needs. The methods of achievement are principally by the reduction and prevention of water pollution at its source and by utilization or treatment of all wastes ordinarily discharged into water. The total quantity of water made available for use will be limited, of course, to the rainfall and natural run-off potential of the watershed under development. Availability when needed is dependent, however, on the developed storage capacity of the watershed.

The total quantity of water in effect can be increased by efficiency of use and reuse through management of quality. This involves two important management principals: (1) planning and (2) control; applied, for effective results, in a manner that is dynamic, practical and acceptable. Review and evaluation are needed on a continuing basis. Management skills include forecasting and research, defining performance criteria, devising adequate controls, making appraisals, and developing essential awareness for action through adequate communications.

Water quality management undertakes responsibility for accomplishing the over-all aim of an adequate supply of water of quality satisfactory for all uses. Parameters for determining quality related to various water uses are fundamental in every practical and effective program for control of water pollution. Analytical methods and proper interpretation of results are an integral part of evaluating quality.

WATER QUALITY OBJECTIVES.

Following the establishment of basic aims or goals, and selection of a system for their attainment, procedures of management will usually involve early adoption of water quality objectives, or 'yardsticks' of quality based on water use. Such objectives have been adopted by Canada and the United States for use in the Great Lakes Basin. They help define parameters required for interpreting broad objectives. The way quality needs very with water usage is apparent from the following examples. Sources of public water supply must be amenable through reasonable purification procedures to provide clear, clean, taste-and-odor-free water for domestic use, relatively low in mineral content and free from disease producing organisms, viruses and toxic substances. Suitability of water for agricultural use is based largely on mineral content,

especially the presence of sodium and other cations, and of boron. Recreational waters need to be relatively free from domestic and industrial wastes and capable of supporting fish and biota constituting aquatic and wildlife food. Water quality for industrial purposes covers a wide range of requirements depending on end use - a high degree of purity being necessary for food processing, for instance, where potable water criteria must be met, while for cooling water, not in contact with a product, low temperature would be the major requirement. Water quality needs for power generation and navigation generally are less exacting.

PLANNING CONSIDERATIONS

In planning a water quality program for a management area, usually a basin or watershed, the following basic elements in the general situation are among those considered: (1) the variable relationship between stream flow and water quality; (2) location of, and factors affecting, users of the water; (3) present and future requirements and kind of use; (4) waste-absorption capacity of each stream or body of water involved; (5) water storage available for dilution of stream flow to maintain or improve quality; (6) waste treatment facilities in operation, under construction, or to be built; (7) capability of the stream or other basin waters, including municipal and industrial plant effluents, for reuse; and (8)estimated population growth, industrial expansion, and recreation and other water needs for extrapolating requirements for years to come - say, 50 years in advance.

Planning necessitates delving into all information concerning the basin or watershed, with the devising of ways and means for acquiring needed information when not otherwise attainable. For instance, basic data on water quality kept up-to-date under a continuing program is fundamental. Such data for sections of the boundary waters is obtained under the surveillance program of the International Joint Commission. In addition, the U.S. Public Health Service maintains a national water quality network. Many State and Provincial agencies, municipalities and industries are cooperating. Network results are published regularly. The most recent U.S. water quality network report has just been made available.

Planning is linked with review and evaluation. Planning indicates what we are to do; review, if effectively done, tells where we are. This is a continuing process. Knowledge gained, transmitted to those making decisions, can help greatly in the continuing round of planning and action.

Since extent and comprehensiveness of each area management program will be shaped by local financial participation, water quality management for the area is designed for application to parts as well as to the whole.

Extent of the program is governed in a large degree by local attitudes. A progressive area is usually far-sighted enough to sacrifice immediate returns for larger and more lasting benefits in the future.

Although every water quality management program should have as its aim full use of all water resources in the area, programs are developed in intermediate stages. The base for the program may need to be broadened, such as being undertaken through a program started last year in the Lake Michigan portion of the Great Lakes Basin.

Public awareness of needs is an essential factor in gaining support for the program. Newspapers, radio, television and other public information media aid greatly in telling about the program, and in gaining the backing for a course of action or needed improvements. Readiness of the people in the boundary area to share the cost of the program has great influence on its consummation. Their financial participation is an essential ingredient of all of these endeavours.

Forecasting of impacts on water resources of developments in the vicinity of the boundary is of major importance in looking ahead. In every instance there are technical, legal, economic and political considerations - none of which can be safely overlooked. If limits, as determined by water supply or pollution control capabilities, are exceeded, scientific research must produce breakthroughs in quality control techniques such as a new solution for a stubborn industrial waste water problem.

CONCLUSION

There is no cheap or shortcut method for managing the quality of these vital resources in meeting growing water needs of Canada and the United States in the boundary areas. However, much of the technical knowledge is available, administrative patterns can be resolved, and there is reason to believe that recent trends will continue to develop on a sound, economical and practical basis, assuring water resources quality suitable for the multi-purpose uses of these boundary waters.

Farsighted international action has provided the treaty on boundary waters between Canada and the United States, and authorized creation of the International Joint Commission. It has given us the method for bringing various jurisdictions together in both countries and has made possible the teamwork so essential in solving water pollution problems of today, and now continues to help expand water quality management activities looking toward ever greater usability of the waters in the boundary areas for the benefit of the generations of tomorrow.

MY COUNTRY

by

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In my pre-medical days, when I had an idea I should be a Theologian, I had perforce to study a good deal about the Bible. I found it a most remarkable volume, indeed one passage in the early pages struck me so forcefully that I have never forgotten the words. And these words I plan to use to-day as a basis or a text for what I want to say to you.

> "For The Lord bringeth thee into a good land, a land of brooks of water and fountains that spring out of valleys and hills; a land of wheat and barley and vines; a land of oil and honey; a land wherein you shall eat bread without scarceness you shall not lack anything in it; a land whose stones are iron and out of whose mountains you may dig brass".

And so I want to talk to you about My Country, and I have titled it so rather jealously for I need not tell you it is not the land of my birth, but rather the land of my adoption. It is the land of which I am a citizen by choice and not by chance that I mean when I speak of my country, for it is with a deep sense of jealous pride that I say as I parody one of our contemporary educators; "Not a Canadian born, or a Canadian bred; but when I die, there's a Canadian dead". Nor do I say my country in the sense that I have possessed her, but rather that she has possessed me and has opened doors of opportunity that could never have been opened otherwhere. My Country I call it because that is how I would that everyone living within the bounds of this great land should think and feel about it.

But before I stray too far from my text, I would make it clear to you that I have no intention of preaching a sermon to you, but

rather I want to proclaim a faith which I am sure will strike a responsive chord in many of you here to-day. Nor shall I presume to tell you that Moses had Canada in mind when he wrote the words I quoted to you, but none can deny that he may well have referred to our land, for his words describe Canada as surely as they did the Promised Land to the weary children of Israel as they fled the slavery of Egypt and the whip-lash of the Pharoes; his words describe Canada as few writers have ever done, and too, I believe, they bring to our mind that even in our own times this is and has been indeed; THE PROMISED LAND ...... to untold thousands; a land where we may eat bread without scarceness, we shall not lack anything in it .....

Now I do not think it has always appeared as a promised land. I cannot think that the Cabots, John and his son Sebastian were overly enthusiastic when they first rounded the coast of Newfoundland in 1497. To them it was a desolate, rocky, heavily forested mass of land, shrouded in mists and fogs, bleak-looking and forbidding. The only promise it held for them was that this seemed to present the long sought for "short cut to the East". Jaques Cartier in 1535 was a little more enthusiastic for he sailed up the St. Lawrence and saw the rich hardwood forest, stretching in park-like reaches down to the lush meadow grass land along the river banks. But then he lost the promise when he reached the treacherous and un-navigable waters of the Lachine Rapids. Add to this his unfortunate experiences with the natives of the stockaded village of Hochelaga, the tremendous toll taken of his crew by the rigorous winter climate and the dread scourge of scurvy. Yet some inner instinct must have guided or driven Cartier for he did return to France to re-equip for a more extensive voyage of exploration, one which, however, was even more tragic and less fruitful than the first.

Then we turn the pages of history to a somewhat more brilliant one to us; to the time when Wolfe sailed up the St. Lawrence to storm the very front door of the then New France. But to him this land could not have held much promise either as he stood on the bridge of the Flagship, one of the youngest Generals in Britain's military history, a lonely man of 33, already sickening unto death, and pondered the task that lay ahead of him. And task indeed it was, for he had been virtually ordered to deliver to his quite ineffectual monarch almost half a continent, and all he saw was sheer cliff and forest and turbulent waters about him. I need not recount the details of how he accomplished his task; indeed the telling would take longer than the battle for some historians tell us it lasted only 15 minutes, but with the outcome there passed to British control this great land.

Now we might profitably spend much time on the subsequent history, but I submit to you that Canada's true greatness began only in the latter half of the 19th century when on July 1st, 1867 a Royal Proclamation brought into being the Dominion of Canada, culminating years of effort and the sublimation of widely diverging political views and even personal hatreds and animosities by those Fathers of Confederation who realized that

the very existence of their beloved land was at stake so long as they presented to the world a divided front. Only 4 provinces joined to form the New Dominion and it took more than 80 years to complete the task, but to-day Confederation is well rounded out to include all 10 provinces.

The first 30 odd years were years of steady tho' slow growth and development, for the young country had to find herself first; but with the dawn of the 20th century Canada's star was in the ascendancy. Sir Wilfred Laurier I think it was who said in one of his great prophetic utterances, "The 20th century belongs to Canada", and I am sure he spoke more wisely than even he dared to dream.

Then a land of some 3 1/2 million square miles and with a population of only some 5 million people, Canada now has a population in excess of 18 millions. In 1900 forest covered more than 1 1/4 million square miles of our country, and even though our shameful waste and exploitation of this natural asset should stand to our lasting shame, this industry has been so developed that we now stand 3rd in the world as a producer of board lumber, sawlogs and veneer logs, in addition to supplying 60% of the entire world supply of Newsprint.

AGRICULTURE, always the basic industry of Canada, has run a parallel course till to-day we have more than 62 million acres in crop, producing half a billion bushels of wheat which, for quality, has no equal in the world; almost twice that amount of coarse and feed grains. Add to this 1/3 of a billion pounds of butter; 120 million pounds of cheese, 10 million pounds of wool, beef, pork product, lamb, etc. in almost astronomical quantities, and you cannot fail to be impressed, nay even startled by the tremendous production potential of our land.

A backward nation, some have dared to call us beside our great neighbour; they have not seen our cities - Vancouver on our western approach, a proud but mighty young giant; Edmonton, nestled in the foothills reaching long limbs in all directions like a youth outgrowing his clothes; Saskatoon, likewise seeking to spread her bounds wider still and wider; Winnipeg - perhaps more cosmopolitan than any city on the continent standing like a colossus athwart the gateway to our prairies; Toronto - the fastest growing city on the continent to-day; Montreal, that mighty seaport on our east, beckoning in welcome to all who approach that entrance to this land of promise; and even Old Quebec, she, too, is stirring to shake off the staid calm of the old world that she might launch forth into the deeps of the progress that shakes our entire land. A backward nation - yet no other 18 million people have produced more, earned more, subdued more or built more than we have done here.

"A land whose stones are iron ..." Is that not even more literally true than the rest of the text? Few Canadians can possibly be ignorant of the saga of mining and mineral production in this nation. In 1900, the value of mineral production was 64 millions of dollars; now it exceeds a billion dollars, garnered from 66 different mineral products more than half of these discovered in the last 25 years. This Canada of ours ranks <u>first</u> in world production of Nickel, Asbestos and Platinum; <u>2nd</u> in production of Gold, Aluminum, Zinc, Cadmium, Selenium,

Radium and Uranium; 3rd in the world for Silver production; 4th for Lead, Copper, Cobalt. And one could go on to add many more, for have we not in our own time been thrilled with the new rich finds of Iron in Labrador, (Here great new deposits in Ontario), Titanium in Quebec, one of the largest single sources yet found in the world, and the almost daily reports of new sources of oil in our great west, where producing wells are being brought in with amazing regularity. And what might we say of that newest source of natural energy - Natural Gas, with its mighty potential for the economy of our Nation.

So runs the same thread thro' the warp and woof of our Nation's history in every field of endeavour. In 1900, our labour force numbered less than 2 millions; now, it exceeds 6 millions; then we produced about 1/2 billion dollars worth of manufactured goods, now we produce about 23 billion dollars worth. At the beginning of the century, Canada had no assets abroad; now we own in excess of 6 1/2 billion dollars in this sphere. We are now the third trading Nation in the world with a gross National product of over $36 Billion. This only touches upon the main things which count for much in our Land; these are the tangibles, the material things, the things we can touch and see and can evaluate in dollars and cents.

But is this the only thing that makes a nation great? No, Gentlemen, I submit to you that the intangibles, the values we know and feel, but upon which we cannot put a dollar value, are at least of equal importance to the continued development and greatness of our country. These are the things that have been bought, the assets that have been accumulated and built up at tremendous cost, not of dollars and cents or goods, but of devoted service and sacrifice of self and even of life on the part of thousands of the sons and daughters of this Canada. And I believe they gave because they believed this to be a good land, and they gave in the hope that we would recognize this fact and keep it as such. I need not recount to you these intangible values except to remind you they are the most difficult to guard and protect. Think of the Freedoms we enjoy; freedom to speak without fear of reprisal so long as we do not speak sedition or slander; freedom to worship according to the dictates of our conscience with no suggestion of control of any sort; freedom to gather together in groups, our clubs, our lodges and societies, without the shadow of a Police State ever hanging over us; freedom from want and hunger; freedom to work out our own destiny, so long as we do not try to force our will upon our fellows. And there is something else here for all to grasp and to enjoy - something we appear to lose sight of in these days - that is Opportunity. It is here a-plenty in this great land of ours, waiting to be grasped. It is no cliche - no pious platitude that a young man or young woman can be and do what he or she WILLS to be or do in Canada - not "wants" but "wills" - there is a difference. I say this is no pious platitude but a fact proven by experience.

Perhaps we should revise our sense of values ... perhaps we place too much emphasis upon security - we might do well to exchange that word for an old and popular but little used word now - ADVENTURE. We need a re-awakening of the pioneer spirit of a century ago - the men

who are willing and anxious to dare - to adventure forth - not to carve new homes from wild wilderness, but men with a vision of a faith in the great future of Canada to blaze new trails in the development of our Nation, all the while guarding jealously the rights, the freedoms, the opportunities that are ours. These are the things we must hold and protect if we are to continue to be and to grow great; they make our country a GOOD LAND.

Through the "Blood, Sweat and Tears" of two world conflicts - conflicts mainly of opposing ideologies, and rocked to her foundations by an economic upheaval, the like of which we are told the world has never known, Canada has plumbed the depths and risen anew, looking neither too far to the left nor to the right, but following a reasonable middle course, aiming ever toward the goal that lies ahead.

From a not too well considered colony, to what I believe will be "the brightest gem in the diadem of our Commonwealth", and a leader of great influence among the nations of the world all in the short space of some 50 years is in itself enough to merit the reputation of a Good Land. And this we must remain; but we need to bear ever in mind this incontrovertible fact, that we are not without enemies; forces both within and without, that seek to undermine, particularly those intangible assets I have mentioned, and to force upon us their ideologies, their philosophy of life. They do not seek to lift the downtrodden, over whom they shed their great crocodile tears; no, rather they strive to pull down the great mass of free and freedom-loving people to the level of serfdom, and they do all this in the name of peace and freedom. Against these, I urge, we need to be on our guard. But be not mistaken; I would not inflame any to a rabid or narrow Nationalism, for that, too, will surely lead sooner or later to the loss of our freedom. I only urge that we take home to ourselves the words of the Patriarch, and strive constantly to guard with jealous care those intangible values that have made ours a Good Land, for be assured, if these values are upheld, our material growth cannot be retarded, and by the upholding of them we will be helping Your Country ... My country ... to rise to that level of true greatness that ever has been her Destiny.

This is My Country - young and full of doubt, but restless and eager, believing that now our time has come and we are ready.

SESSION NUMBER FIVE

A. V. DELAPORTE,
Consulting Engineer,
Session Chairman.

EXPERIENCE IN CONTROL OF POLLUTION FROM INDUSTRIAL WASTES IN VIRGINIA

by

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A scant 20 years ago the unregulated discharge of wastes from great centres of population and industrialization in some parts of the United States had so degraded the quality of many streams that the water, though in most instances plentiful, was unfit for use. As the post-World War 11 boom began to gain momentum it became increasingly evident that there would soon be keen competition in many areas for the available quantity of unpolluted water. Restoring the quality of polluted streams in some of these areas was the obvious answer to increasing the quantity of usable water, and State after State began to adopt laws having as their objective the improvement of stream water quality. These laws are generally referred to as comprehensive laws for the abatement and control of stream pollution.

Virginia adopted such a law in 1946. It is known as the State Water Control Law and is administered by a five-man group known as the State Water Control Board. The law gives the Board the responsibility and sets up administrative machinery for (1) bringing pre-1946 pollution under control and (2) preventing the creation of new pollution.

Accomplishing these two objectives requires, in the first

instance, determining the extent to which the quality of a polluted stream may be improved to restore its usefulness for other purposes, and in the second, determining how much impurities from waste matter may be added to a stream and still retain a sufficiently high quality not to impair its usefulness for other purposes. In either instance, a decision must be made regarding the threshold of quality, or purity, which, if crossed, constitutes "pollution".

ESTABLISHING STANDARDS

In the past four or five years the subject of water pollution has been especially widely publicized in both the technical and the popular press. A great many people talk glibly about the "great amount of pollution" that is getting into the nation's waterways, or how much "pollution is increasing", or perhaps how the newer and exotic wastes of today's industrial technology are "adding to stream pollution". While the meanings of these expressions are plain to both professional and lay people, legally they have no meaning under most of today's comprehensive water pollution control laws in the United States.

"Pollution" is a general term. It may be compared to words like "big", "tall", "poisonous", "deep", and a hundred similar ones. To say that something or someone is "tall" means nothing unless there is available a yardstick or other standard for comparison. A tall man is short compared to a tall tree or a tall building. A fat man is small compared to a fat elephant, or a fat whale.

What, then, constitutes pollution of water? Under the old English Common Law, which still forms the basis of both the written law and court precedent in many of the United States, it is a condition that occurs when foreign matter is present in water in such quantity, condition, or manner as to make it infit for use. Definitions of pollution in comprehensive stream pollution control laws in the United States and elsewhere are all legally-worded variations embodying this basic concept. The definition in the Virginia Law, for instance, states that pollution

> " ... means the discharge or deposit of sewage, industrial wastes, or other wastes, in such condition, manner, or quantity, as may cause waters of the State to be contaminated, unclean, or impure to such an extent as to make such waters directly or indirectly detrimental to the public health or to the health of animals, fish or aquatic life; unsuitable with reasonable treatment for use as present or possible future sources of public water supply or unsuitable with reasonable treatment for such water supply by reason of impairment of potability due to such discharge or treatment required to safeguard such discharge; or unsuitable for recreational, commercial, industrial, agricultural, or other reasonable uses ..."

But this broad definition is useless unless it is possible to specify how much of each specific substance present as an impurity in a stream constitutes too much consistent with each use of that stream. Obviously, how much is too much depends on the specific impurity or group of impurities, the character of the stream, and the specific uses of the stream to be protected. Presumably there is for each and every foreign substance that may get into a stream a definite concentration, which if exceeded, makes the water unfit for some use. These limiting concentrations are the yardsticks by which water pollution control law administrators judge the fitness of water for various uses.

Therefore, a water pollution control law, in addition to defining pollution in general terms, must also give its administrators the authority to set, secure, and maintain standards of water quality consistent with those stream uses which they deem it is in the public interest to protect. The Virginia Law does so, giving the Board the duty and authority

> "To establish such standards of quality for any waters in relation to the reasonable and necessary use thereof as it deems to be in public interest, and such general policies relating to existing or proposed future pollution as it deems necessary... to modify, amend or cancel any such standards or policies established and to take all appropriate steps to prevent pollution contrary to the public interest or to standards and policies thus established".

It may be seen that the Board need not necessarily hue strictly to technical or scientific data when it establishes standards. As a rule, they should be set more rigidly than the technical data would indicate. Allowing a factor of safety where doubt exists, as for instance, in the case of toxic substances, is certainly justified. There is also justification for setting standards high enough to maintain a reserve capacity for assimilation of additional waste loads from possible future new or expanded industries, and growth of municipalities. On the other hand, if the public interest would seem to justify it - though this is certainly contrary to the present thinking of the Board, and its doing so seems extremely unlikely - a stream could be dedicated, to the subordination of all other uses, exclusively for waste disposal, and assigned very low water quality standards. Also, the Board might, in the public interest, establish standards which protect a stream for some uses but not for others. Furthermore, it may set standards quite arbitrarily, so long as there is a sound reason for doing so. The Board must use the facts involved in each case, and then apply its best judgment in making a decision.

In discussing standards, a word regarding so-called "natural pollution" may be in order. It is quite possible for a stream to contain little or no impurities from man-connected activities and still be so degraded from purely natural sources as to be unsuitable for certain uses. An example is a flashy stream that

becomes so highly turbid it cannot be used as a water supply. Another example is a highly colored swamp stream that normally contains only a small concentration of dissolved oxygen because of the natural organic load it carries. Other less common examples could be cited. Even though it may have the authority to do so, there is usually little that a regulatory agency can do about improving the quality of such streams.

In the final analysis, then, pollution is nothing more or less than a legal term meaning that water quality standards have been contravened. Conversely, if standards duly set by law are being maintained, legally the condition known as pollution does not exist.*

All of the above seems straightforward enough, but the setting of reasonable, equitable and enforceable stream standards is undoubtedly the most difficult task faced by a regulatory agency. In the first place, though there are mountains of literature on the subject, the truth is that there are many substances about whose effects on the usability of water there is little or nothing known. Even when published information on a particular substance is available, there is no assurance that it will react in accordance with this information when discharged into a particular stream. Finally, for standards to be enforceable, the substances on which limiting concentrations have been set must be capable of being detected and their concentrations determined. This means that appropriate chemical, physical or other analytical methods must be available. But even if all these conditions are met, actually monitoring the concentration of a particular substance in a particular stream may be difficult, and often expensive as well.

ADMINISTRATIVE PROBLEMS

In view of all of these difficulties, it is not surprising that pollution control agencies have resorted to administrative expedients and dodge the problems involved.

At this point it is well to consider for a moment the basic position of the typical regulatory agency in the water pollution control field. These agencies almost all operate under so-called administrative laws. While their decisions are usually subject to review by the courts, they are practically invulnerable to attack against their arbitrary and unfair actions, since (1) such actions have the force of law until set aside by the courts, and (2) court action is inconvenient, expensive and time consuming. Even if an industry should win a court case against a water pollution control agency, there is always the feeling that this might be an impediment to its future relations with the agency. Consequently, most industries would tend to abide by unfavourable administrative decisions rather than go to court.

* It should therefore be clear that there are, strictly speaking, no "degrees" of pollution. Streams may be compared according to the degree of quality degradation, which varies with the types and relative amounts of impurities they contain, but it is not proper to say one stream is more or less polluted than another. However, custom being what it is, the term "pollution" will doubtless continue to be used by lay and technical people alike instead of the more proper and precise terms "contamination", "adulteration", "degradation", and other similar ones.

It is therefore obvious that a regulatory agency, and especially its day to day administrators, must guard against wielding unauthorized, arbitrary, capricious and unjust power. In this respect, it has been gratifying to the Board and its staff that it has gained a reputation of administering the Law firmly, but yet reasonably and fairly.

The Virginia Board probably works harder and operates with less formality than comparable bodies in other states. It has attempted wherever possible to accomplish by conferences (at both Board and staff level) and informal directives the corrective measures deemed necessary to abate pollution. Of course, it has the authority to hold formal hearings and issue orders, but most of the hearings it has held have been in the case of municipalities. Industries, for the greater part, have cooperated without the necessity of formal action.

Progress resulting from such an approach has probably been as rapid as would have been the case under a more aggresive approach. The latter would probably have resulted in considerably more litigation, the formalities of which would have tended to slow down the program. However, even if the Board had wanted to carry on a more aggresive program, it would have needed a much larger staff and budget to make it effective.

ABATING "EXISTING" POLLUTION

The Virginia Law became effective on July 1, 1946. In order to understand the problem that faced the Board with respect to abatement of pollution then existing, reference to figures 1 and 2 is helpful.

Figure 1 depicts minimum flows of one or more day's duration of the larger streams in each major Virginia river basin. As a basis for setting standards, the minimum five or seven-day average flow statistically determined to be exceeded 90 per cent of the time is usually used.* In other cases, more or less frequently occurring flows are used.

Figure 2 depicts localities in Virginia where in 1946 the heaviest municipal or industrial waste loads, or both, were being discharged so as seriously to degrade water quality of the receiving streams.

The problem of reducing to desirable limits the loads to streams in each of these localities brought the Board headlong into the problem of setting standards. It was apparent that substantial progress toward stream cleanup could be made without first making surveys of all streams to assess their then-existing conditions and the formulation of standards. On the basis of observation and judgment alone, it could be seen that not only

* These so-called 10-year flows will usually be higher than those depicted in figure 1.

were many streams damaged beyond use, but also that every possible ounce of the impurities responsible would have to be taken out to restore them to usefulness. Other streams were obviously less seriously damaged, and some appeared not to be affected at all. This, of course, is not substantially different from conditions existing in other states when they embarked upon pollution control programs, but the Virginia Board's approach to correction was perhaps different.

Having taken only enough time to get organized, the Board proceeded to serve notice on all then existing industries and municipalities** discharging wastes into State waters that they must (1) initiate programs for abating any pollution they were causing, and (2) report quarterly the progress they were making in carrying out such programs. Then it concentrated its efforts on those owners whose wastes were causing the most obvious stream damage, pressing them to take without delay such action as was apparent and feasible to reduce their waste loads on these streams. The question of water quality ultimately to be maintained in each case was, for the time being, left unanswered in most cases.

Such a procedure appears to be in line with the thinking of the General Assembly (legislature) in 1946, which specified that the results to be obtained by an owner in compliance with any order or requirement of the Board must be "reasonable and practicable of attainment". Some of the 1946-vintage pollution was a long time in the making, and the General Assembly wisely reasoned that it might not always be eliminated quickly. It left to the Board's discretion, taking into account the public interest, to determine how fast such pollution was to be stopped.

It was not until after those industries having the worst problems were effecting such improvements as could immediately and expediently be made that the Board began making the most urgently needed stream surveys to permit formulation of at least preliminary, and generally broad, water quality objectives to be attained as a result of the cleanup activities.

Some of these surveys had to be cooperative ventures, since the task in some cases was too big for the Board to accomplish alone. In these instances the Board obtained the assistance of the municipalities and industries of the area, who contributed services, material or personnel to make the surveys. The Board's contribution was in kind, and it retained general supervision and coordination of the surveys. This procedure eliminated the necessity for any direct contribution of money by any of the participants, which facilitated greatly organizing and carrying out the surveys. This method, incidently, has not been used in recent years, since the Board now has a larger staff, but it can still be recommended as one of great value and expediency.

** While the Law allows the Board considerable leeway to decide how fast pre-1946 pollution is to be abated, it specifies that no new industrial establishment may be started, or an existing one expanded, until facilities have been installed to prevent pollution from any new or increased amount of wastes. The same thing applies to new subdivisions, or to substantial additions to municipal sewerage systems.

It is only now, after almost 15 years, that the Board is thinking seriously of formalizing many of its previously used objectives by setting standards. During this time a considerable amount of stream survey data has been obtained by the Board and by a number of industries, and the effects on water quality of load reductions are known in most areas. In three or four instances streams have not been improved as much as is desirable, despite sizable reductions in the loads from the industries and municipalities responsible. In at least two of these cases, there is no known answer to maintaining satisfactory water quality, short of shutting down the plants.

One of these, a soda-alkali plant, has been able to reduce its chloride load on a stream to only 5000 parts per million, when a reduction to perhaps 100 parts per million is needed consistent with present uses. The Board has held a number of hearings involving the plant, but it has not yet made a determination as to which is in the public interest, a clean stream without the industry, or the presently polluted stream with the industry. In other words, the Board has not yet decided whether an order to the industry to maintain 100 parts per million of chlorides in the stream would, as is specified by the Law be "reasonable and practicable of attainment". It has taken the position that quality standards on this stream must be related to the ability of the polluter to carry out a practical program of abatement.

The wastes cause damage to water uses in an adjoining state, resulting in interstate pollution as defined by Public Law 660, the Federal Water Pollution Control Act. The Federal Government has been called into the case, but it seems inevitable that the enforcement division of the United States public Health Service will come to the same conclusion as the Virginia Board. This is thought to be the only instance where the Federal Government has entered a case of interstate pollution to which there is no known feasible method of accomplishing desirable stream quality objectives, except to shut down the plant. It will be interesting to follow this precedent-setting case to its final adjudication.

EFFLUENT STANDARDS

Pollution control laws are enacted for the primary purpose of protecting streams. Every other provision they contain is only incidental to accomplishment of this purpose. But, as has previously been pointed out, monitoring a stream is not always an easy task. One of the administrative expedients used to circumvent this difficulty is the use of so-called effluent standards.

As a means to an end, effluent standards are in themselves not objectionable. Samples of waste discharges may usually be more conveniently collected and analyzed than samples from streams. Therefore, effluent standards are much easier to monitor and to enforce. However, protection of the stream should be the end toward which effluent standards are directed, and they should therefore be set in relation to stream standards.

Standing by itself, a blanket requirement that all effluents in a state shall not contain more than a certain number of parts per million suspended solids has little meaning. In a large stream that naturally carries a large suspended solids load the standard is probably too rigid, while in a very small stream the solids could cause a nuisance, especially if they were organic. Suppose, for instance, it is assumed that 400 parts per million of organic suspended solids in an in dustrial effluent discharged to a stream will not cause damage at design low flows. Obviously, if no more than 400 parts per million suspended solids is maintained in an effluent at all times, the stream standard will always be met. However, the industry will be paying a premium, during higher than design stream flows, for removing more solids than are necessary. It may be conjectured that if the Board found an effluent standard was being contravened during stream flows greater than design, the industry could not be prosecuted for polluting a stream, unless the stream standard upon which the effluent requirement was based was being contravened. It is the stream that, in the final analysis, is the "proof of the pudding".

The Board has actually used the expedient of effluent standards on several occasions, but in each case they were related directly to stream standards. In one instance the Board required than an industry maintain not more than a given concentration of cyanide in its effluent, but this was based on maintaining not more than a given concentration in the stream at the minimum 5-day flow expected to occur 90% or more of the time. In each of the other instances it had no other choice, since the receiving "stream" had a natural minimum flow of zero, meaning that the only flow during these times was confined to that of the effluent itself.

APPROVAL OF PLANS

To meet stream quality standards, an industry has the choice of either regulating its processes so wastes are eliminated or minimized, or installing waste treatment facilities. Construction of waste treatment facilities means that plans must be drawn. It has been traditional for state departments of health to approve plans for municipal sewage treatment plants prior to their construction. The Virginia Law specifies that an owner must submit such "pertinent plans, specifications, and data as may reasonably be required in scope and detail satisfactory to the Board ..." for facilities to dispose of wastes from new industrial establishments or from additions to existing establishments. However, the Law does not require the Board to review plans for facilities to abate pre-1946 pollution. The laws of most other states, with the exception of at least one - California - have similar provisions. The objective of these provisions is obviously to permit the regulatory agencies to judge as well as possible, before any discharges are made, whether the stream standards they establish will be met. The question then arises as to how detailed a study they ought to make when they review plans for industrial waste treatment.

It would be possible to discuss at great length the philosophy and basic principles involved. Suffice it to say that the Board's

staff, in reviewing plans, makes the assumption that a process is being approved, but not the structures, nor the details of the structures. To this end, detailed plans and specifications are not normally required - only such drawings and specifications as are needed for an overall evaluation of the treatment process. Attempts are made to determine if there are any obvious inconsistencies or errors. If there are deviations from what is generally accepted practice, the engineer is asked to justify the deviation. In matters involving differences of opinion, the practice has generally been to note the difference and allow the judgment of the owner or his consultant to prevail.

The Board's staff believes, perhaps somewhat idealistically, that the emphasis of regulatory agencies should, insofar as is consistent with law and good administrative practice, be on maintaining satisfactory standards of stream water quality and not on the details of how each individual owner accomplishes his compliance with these standards. Admittedly, this viewpoint is at variance with traditional thinking and with the practice in most states, but it is in harmony with the viewpoint that governmental regulation should be as less onerous as possible. If the art and science of waste treatment is to flourish, consulting engineers must be free to practice their profession in the design of new and novel facilities.

There are those who would argue that such a philosophy denies the regulatory agency adequate control over those discharging wastes into streams. While some owners would perhaps be inclined to take unfair advantage of such a policy, the great majority of situations are not so serious that they warrant the imposition of harsh or unreasonable requirements, at least not until the owner shows lack of good faith. If the situation becomes serious, it is believed that most regulatory agencies have adequate power to effect correction through (1) administrative procedures, such as the issuance of orders and (2) court procedures, such as through levying fines or writs of injunction or mandamus.

Most regulatory agencies, unfortunately, are not willing to be very venturesome in this respect. In California, however, the practice of not approving plans for waste treatment as a prerequisite to discharge of wastes into state waters seems to be satisfactory. The owner there is given the stream or effluent quality standards to be maintained, and he must then discharge his wastes so as not to contravene them. How this is accomplished is not the concern of the State of California.

Though this paper is not intended to deal with the subject of sewage, it is interesting to note that the Virginia Law requires plans for sewage treatment to be reviewed first by the Virginia State Department of Health, which then passes them on to the Board with a report either approving or disapproving them, and then by the Board which makes a final review and either approves or disapproves them. In contrast to the Board's staff's rather casual review of industrial waste treatment plans, the State Department of Health makes very detailed reviews of the construction plans and specifications for sewage treatment plants.

In defence of the Department's practice, it is well to point out that in the field of sewage treatment there is general agreement as to design criteria applying to processes and process units, and as to what constitutes good practice. Furthermore, construction of sewage treatment facilities more often than not involves the expenditure of public funds by municipalities whose personnel are totally incapable of judging the adequacy of the plans. In the field of industrial waste treatment, "cookbooking" of plans is generally not possible, and the regulatory agency's review may well turn out to be simply a pitting of its judgment against that of the owner or his engineer.

INDUSTRIAL POLLUTION ABATEMENT PROGRESS

Most of the new wet process industries and some expansions of existing industries have required the installation of waste treatment facilities to prevent pollution. By contrast, most of the pre-1946 industrial waste load to Virginia streams has been removed, and pollution abated, by means of in-process changes and other means short of external treatment. There have been several significant instances of pioneering in the development of both industrial waste treatment methods and chemical recovery processes for stopping pre-1946 pollution, or at least improving water quality. In all the areas shown in figure 2, improvements ranging from little to complete have been made.

In 1946 the pulp and paper industry contributed the greatest load to Virginia State waters. While this is still true, the individual loads have been so reduced at nearly all locations that water quality is at or near desirable levels.

Other Virginia industries having heavy process waste loads to state waters, and who have made significant reductions since 1946 include menhaden fish processing, textile, pharmaceutical, viscose, and food processing.

STREAM QUALITY MONITORING

Since water pollution control agencies have in the past generally suffered from shortages of personnel, equipment and money, they have not been able adequately to monitor their stream water quality requirements.

Setting water quality standards and seeing that they are maintained is not unlike the setting and policing of highway speed limits. The driver has the responsibility of maintaining his vehicle in good order, including instrumentation for indicating or recording speed and other conditions. The highway police have the responsibility of determining, by appropriate means, such as patrolling and the use of radar, who is contravening the speed limits.

The owner discharging wastes into waters on which standards have been set has the responsibility of maintaining waste treatment and disposal facilities in good order, and of determining, by means of appropriate tests and measurements, the amount and composition of its wastes, as well as of the receiving waters. The regulatory agency

has the responsibility of making such tests and measurements of streams as are appropriate to determine if standards are being maintained. While there may be some difference of opinion as to the above distribution of responsibility, there can be no question as to the necessity for obtaining the data.

Most of the major industries in Virginia regularly monitor their waste discharges and the streams that receive them. The Board has a network of stream monitoring stations throughout the state, from which samples are taken at least once a month and analyzed in the central laboratory. This network needs to be expanded greatly, both in regard to number of stations and frequency of sampling, but personnel limitations have thus far been a restraining influence.

Industry expends much effort and money to develop fast and continuous methods for measuring and controlling the quality of the products it manufactures. It seems high time that the same emphasis should be put on the development of similar methods to measure and control the composition of its waste water, and to measure and record stream water quality. The time is fast approaching when grab samples from streams collected monthly, weekly, or even daily, will not be sufficient to track quality fluctuations. A plant discharging a toxic material, for instance, should as a routine matter install equipment to record continuously the concentration of this material either in the effluent or in the stream. Such a plant is sure to be suspect every time the local residents see, or think they see, something wrong in the receiving stream. A continuous record is the only sure means by which the facts may be ascertained.

Unfortunately, development of instrumental methods of analysis has not advanced sufficiently far to permit continuous measurement and recordation of most potential pollutants discharged to streams. If stream water quality management is to keep pace with industrialization, there must be considerably more effort expended on the development of such methods. Giving encouragement in this respect are several recent breakthroughs announced by two agencies, the Interstate Commission on the Delaware Basin and the Ohio River Valley Water Sanitation Commission, as well as those by several manufacturers of instrumentation.

It is recognized that the problems of developing suitable instrumentation for stream quality monitoring are great. The pure mechanics of making streamside installations may sometimes be even greater. Obstacles to be hurdled include supplying electric power, providing service and maintenance, telemetering of data and protection against pilfering and vandalism.

The Board's staff is attempting to keep closely in touch with all developments in this field and to adapt them to its stream monitoring program as quickly as finances will permit.

If the problems associated with automatic monitoring of streams are not solved concurrently with America's continuing population and industrial growth, the regulatory agencies will be left floundering in their efforts to carry out effective stream quality control programs.

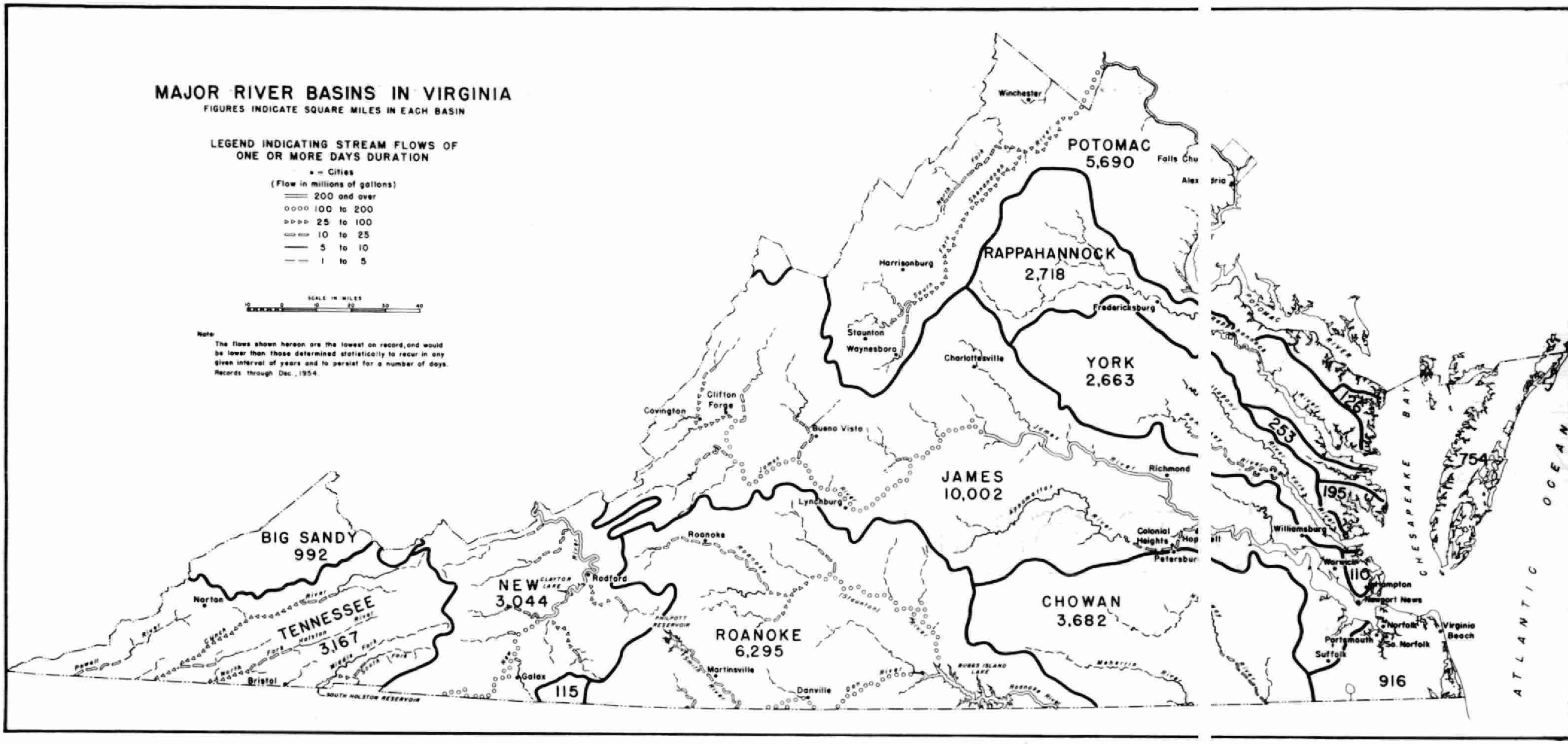
MAJOR RIVER BASINS IN VIRGINIA
FIGURES INDICATE SQUARE MILES IN EACH BASIN
LEGEND INDICATING STREAM FLOWS OF ONE OR MORE DAYS DURATION
• – Cities
(Flow in millions of gallons)
200 and over
100 to 200
25 to 100
10 to 25
5 to 10
1 to 5
SCALE IN MILES
Note:
The flows shown hereon are the lowest on record, and would be lower than those determined statistically to recur in any given interval of years and to persist for a number of days. Records through Dec., 1954.
POTOMAC
5,690
RAPPAHANNOCK
2,718
YORK
2,663
JAMES
10,002
CHOWAN
3,682
ROANOKE
6,295
NEW
3,044
BIG SANDY
992
TENNESSEE
3,167
115
916
110
195
253
754
Winchester
Harrisonburg
Staunton
Waynesboro
Charlottesville
Fredericksburg
Richmond
Colonial Heights
Petersburg
Williamsburg
Hampton
Newport News
Norfolk
So. Norfolk
Portsmouth
Suffolk
Virginia Beach
Covington
Clifton Forge
Buena Vista
Lynchburg
Roanoke
Radford
Galax
Martinsville
Danville
Norton
Bristol
CHESAPEAKE BAY
ATLANTIC OCEAN

Figure 1

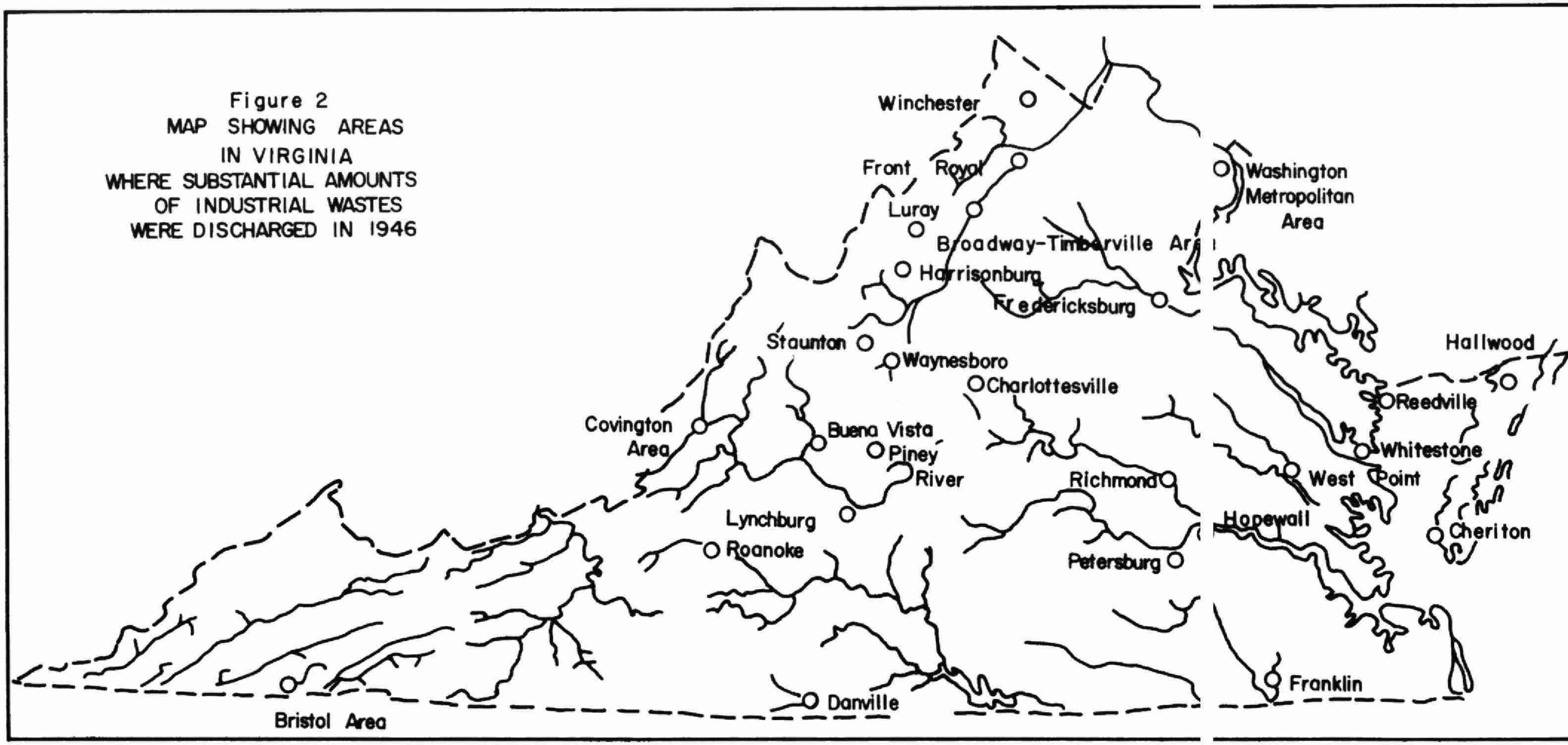

Figure 2
MAP SHOWING AREAS
IN VIRGINIA
WHERE SUBSTANTIAL AMOUNTS
OF INDUSTRIAL WASTES
WERE DISCHARGED IN 1946

THE BANQUET

INDUSTRIAL WASTE - INDUSTRY'S VIEWPOINT

by

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INTRODUCTION

It is well recognized that it is not only economically impossible but also unnecessary to remove all industrial wastes from streams and rivers. Streams and rivers have a certain natural capacity for assimilating wastes without seriously affecting their quality and the rational approach to pollution control, therefore, is to permit the limited use of receiving waters for transporting wastes, regulating this use so that the streams and rivers are still suitable for whatever other purposes are deemed desirable.

The degree of treatment needed for adequate control is a complex problem depending on many factors which must be defined for each local situation. It cannot be resolved by an overall legislative decree or by the adoption of arbitrary or restrictive standards, but depends rather upon co-operative action between industry and control agencies.

Three aspects of the problem will be developed in this paper. They are:

I Industry's View on the Nature of Provincial Control Agencies.
II Industry's Policy on Water Pollution Control.
III Recent Industrial Activity in Water Pollution Control.

I. INDUSTRY'S VIEW ON THE NATURE OF PROVINCIAL CONTROL AGENCIES.

Recently the Quebec Division of the Canadian Manufacturers' Association formed a committee to make recommendations to the Quebec Provincial Government on the subject of legislation for water pollution control. Since this committee was composed of

individuals representing various industries and since the brief was approved by the Quebec Division of the CMA, it can be considered to be a valid industrial viewpoint on the subject of legislation for water pollution control. Certain recommendations contained in that brief are worthwhile considering here.

1. <u>The Composition of a Provincial Control Board</u>

It is generally admitted that the costs and the responsibility alike in this connection are beyond the capacity of any one level of government. It is submitted that conservation of a province's water resources, as well as the control of pollution, cannot be handled by local efforts here andthere. There is need, therefore, for a central body to evolve, develop and implement a well-defined co-ordinated program based on proper research and all available knowledge and experience. Care should be taken to ensure the representative character of such an agency, so that the thinking and advice of all those directly concerned will be brought to bear on the deliberations and the formulation of policies.

Legislation should therefore provide for the appointment of an autonomous Board or Commission composed of representatives from each of the following segments of provincial life:

a) public health services
b) game and fisheries
c) agriculture
d) recreation
e) private and public electric power production
f) forestry, including pulp and paper production
g) processing industries
h) manufacturing industries
i) municipal affairs

2. <u>Powers of the Board</u>

The major activities of the Board should be to ensure the maintenance of public water supplies in a safe condition for consumption and other uses, including the proper treatment of waste before it is discharged into lakes, streams and rivers. The Board should also make arrangements to facilitate the financing of modern water and sewage works.

In order to enable it to carry out these activities, the Board should be given the following powers:

a) to supervise all surface and ground waters used as a source of supply with respect to their quality, and to examine any of them from time to time to determine what, if any, pollution exists and the causes and remedies therefor;

b) to construct, acquire, provide, operate and maintain water works and to develop and make available supplies of water to municipalities and persons;

c) to construct, acquire, provide, operate and maintain sewage works and to receive, treat and dispose of sewage delivered by municipalities and persons;

d) to make agreements with any one or more municipalities or persons with respect to a supply of water or the reception, treatment and disposal of sewage;

e) to construct laboratories, to conduct research programs and to prepare statistics for its purpose;

f) to perform such functions or discharge such duties as may be assigned to it from time to time by the Lieutenant-Governor-in-Council;

g) to arrange for the financing of municipal water treatment and sewage disposal plants, i.e., it should be able to arrange to obtain long term loans for municipalities at the rate of interest paid by the Province of Quebec;

h) to recommend that financial aid, of at least the same value as that provided for municipalities, be extended to industrial establishments required to install facilities and equipment for the treatment of waste.

Apart from ensuring that regulatory measures cause the least possible disruption of industrial activity, which can in itself be very costly, a formula should be involved to provide industry with some assistance in defraying the cost of expensive equipment for the treatment of waste materials. It seems only fair that at least a portion of this financial burden, assumed in the public interest, should be borne by the public treasury.

3. The Personnel of the Board

The Board should be empowered to employ:

a) a full-time general manager, preferably a professional engineer, well qualified in the field of water supply and pollution control; and

b) on the general manager's recommendation, the necessary staff to aid him in the performance of his duties.

As in any other field of endeavour, the degree of effectiveness of the measures adopted to deal with the problem of water conservation and control will depend entirely on the competence of the personnel concerned. The need to ensure that the Board is staffed by well qualified people cannot be too strongly emphasized.

4. <u>The Rules and Regulations to be made by the Board</u>

While the Board should be given power to issue rules and regulations for the carrying out of its duties, it should see to it that they are so drafted as to give them a high degree of flexibility to cope with particular situations. With this in mind, serious account should be taken of the following considerations:

a) In principle, the Board should not issue a set of regulations governing the discharge of sewage or industrial effluent designed to cover all eventualities. Rather, each source of sewage or industrial waste should be considered in relation to local conditions, e.g., the volume of diluting water and other sources of pollution in the locality.

b) Certain general objectives should be set forth as a guiding aim, but the Board should have the power to relax or tighten such objectives with due regard to local circumstances. In this connection, the International Joint Commission on the Pollution of Boundary Waters, following a comprehensive study, advanced a series of objectives for water quality control which have stood the test of time. With minor modifications, similar protective rules are being followed as a guide in both Manitoba and Ontario and the committee recommended that they be adopted for use in the Province of Quebec.

c) After due study, and taking into account all factors, such as the total discharges and the total flow of the river or stream and any other pertinent condition or circumstance, the Board should make a specific set of rules governing the discharge of waste water flowing from a given municipality or industrial plant or any other condition or circumstance coming under their jurisdiction. In issuing such regulations, the Board should also set a limit of time by which the municipality or industrial establishment concerned would be required to comply. In this connection, careful consideration should be given to providing a delay that would be just and reasonable in the light of the conditions imposed by the regulations and other pertinent circumstances.

Those who are familiar with the legislation in the Province of Ontario will notice considerable resemblance between the recommendations of the Committee and the legislation which exists here.

II <u>INDUSTRY'S POLICY ON WATER POLLUTION CONTROL</u>

In considering Water Pollution Control from Industry's viewpoint, one of the most important factors is the policy which has been adopted by industrial concerns with regard to this problem. Through the good offices of Mr. G.C. Bernard, the Manager of the Ontario Division of the Canadian Manufacturers' Association, a number of the

larger companies were asked to supply a statement, in one hundred words or less, outlining their policy with respect to water pollution control.

Sixteen statements were received and they are quoted below. Those companies which requested that their names not be used are identified only by their type of industry.

Campbell Soup Company Limited.

At each of our plant locations in Canada, the Campbell Soup Company Limited co-operates fully with all government authorities with respect to water pollution control. On all new plant installations, we work carefully with the authorities, such as the Ontario Water Resources Commission, to ensure a plant design that will prevent pollution of natural waters. In the case of existing plants, we co-operate fully with the pollution control agencies and other industries in the area to improve the quality of the waste to the required standard.

Canadian Industries Limited

C-I-L policy accords fully with the "Objectives for Water Quality Control in Ontario" as set forth by the Ontario Water Resources Commission.

All new plant installations throughout the Company are to be designed with adequate measures to prevent water pollution. In the case of existing plants where effluents are discharged into polluted streams, the Company will co-operate in every possible way with the other industries in the area, the municipalities and the regulatory authorities to improve the quality of the water to the required standard.

Canadian Oil Companies Limited

The Canadian Oil Companies Limited is in full accord with the objectives of the International Commission for Pollution Control in Boundary Waters. The Sarnia Refinery was designed taking proper account of both air and water pollution abatement measures.

The company co-operates fully with the St. Clair River Research Committee and is continually investigating ways and means to improve control of water pollution.

Cities Service Refining (Canada) Limited

Canada's bountiful natural resources are each citizen's most important inheritance. Properly controlled use of our natural resources can be a great economic benefit and conservation practices which restore them can provide a priceless heritage for generations to come. In this belief, and in the belief that a corporate citizen has much more responsibility than an individual, Cities Service has been conducting a three-fold conservation program since 1958. A major portion of this program has been to make sure that there is no water pollution from the Cities Service refinery.

Cyanamid of Canada Limited

Cyanamid of Canada endorses the "Objectives for Boundary Waters Quality Control" as set forth by the International Joint Commission for Pollution of Boundary Waters and maintained by the Ontario Water Resources Commission. It is also our policy to maintain close liaison with the Ontario Water Resources Commission and to monitor and analyze all effluents on a regular basis in order to control all discharges and product losses.

All new installations are designed to comply with The Regulations and, in many cases, the Commission is consulted prior to the design of the installation.

Dominion Magnesium Limited

The policy of our company with regard to water pollution control is fully in line with the objectives of the Ontario Water Resources Commission.

We are fortunate in that the products, by-products and residues from our plants are of such nature that they are most unlikely to cause water pollution. Acid effluents and effluents from pickling or plating operations which may contain metal salts of a noxious character are readily neutralized, precipitated and clarified by means of our own products or by-products and suitable treatment traps are consistently installed and maintained.

Du Pont of Canada Limited

Du Pont of Canada regards effective water pollution control as an integral part of its operation.

Practical expression of this policy is given in plant site selection, design of facilities and in control procedures in plant operations. At all stages close working relationships are sought with authorities in this field at the Federal, Provincial and municipal levels.

H. J. Heinz Company of Canada Limited

Our company has sought to co-operate in every possible way with the local and provincial authorities in controlling any public nuisance or other harmful results originating from our factory wastes. For many years we have pursued a policy in our plant of segregating storm water and other uncontaminated process effluent from the rest of our process waste water, so that our layout will lend itself to further control and treatment, which we expect to be into in the very near future in collaboration with the local municipality and OWRC.

Imperial Oil Limited

Imperial Oil Limited is interested in all aspects of conservation and water pollution control. Conservation is a way of life. It is the quality of living that is expressed in the cleanliness of the home, the community and in industry.

Imperial, for many years has been active in water pollution control and has been instrumental in developing co-operative research in pollution control in partnership with industry and regulatory agencies of the Provincial and Federal governments. A manufacturer must assure himself of an adequate supply of suitable water and he must plan waste disposal facilities to conform to provincial and municipal regulations for waste water discharge. It is essential therefore that the standards of water quality be clearly defined and understood.

Kimberly-Clark Pulp and Paper Company Limited

The Kimberly-Clark policy is to minimize water pollution as technically and economically sound methods become available. It is expected that each mill within the Corporation will contribute to the program and be alert to possibilities for minor change and development which will abate stream pollution, and will take action on these possibilities.

Libby, McNeill and Libby of Canada Limited

The company operates food processing plants at Chatham and Wallaceburg. At both locations the management has indicated to the municipal authorities and the Ontario Water Resources Commission that they are very willing to co-operate in all respects in reducing water pollution.

The Ontario Paper Company Limited

The Ontario Paper Company has, for many years, been concerned with paper mill wastes, particularly as it affected the local area. Initial work originated during the early 1930's. Since that time, a large part of the company's research has been directed toward waste utilization and so aimed at this problem. Maximum use of the waste materials has been sought and a continual improvement has been shown.

Aside from the economic advantages in waste reduction, the company has maintained its program to conform to the aims of the Ontario Water Resources Commission and to improve the area generally.

Shell Oil Company of Canada Limited

Shell recognizes the inherent possibility of water pollution and its attendant harmful effects arising from petroleum refining and related processes. For that reason, it is a matter of policy in all the company's process installations to incorporate appropriate equipment and operating methods for water pollution control.

A Metal Working Company

The company's policy is in full accord with the objectives of the Ontario Water Resources Commission. In the past certain effluents and by-products have been produced which have not

been in agreement with the standards set forth by the OWRC for streams and lakes in Ontario. Several meetings have been held with the OWRC and other government groups who have a responsibility in this field, with a view to improving the quality of the stream and the lake receiving the waste.

Steel Company "A"

The management of the company has viewed with growing concern the increasing problems of water pollution. In June, 1958, it centralized the responsibility of pollution control in the Utilities Department and some of its main functions are:

1. To co-ordinate the efforts of the various departments concerned with pollution control.
2. To police the company and enforce adherence to accepted standards of pollution control, when such measures are technically feasible.
3. To ensure that all new installations are equipped with adequate pollution control devices.

Steel Company "B"

The long range plan of the company is to contain plant effluents within the limits specified by the International Joint Commission for boundary water control as quickly as is economically possible. The existing facilities are being modified to increase their efficiency in removing water contaminants. New installations will be designed to meet the International Joint Commission's objectives.

The policy statements above certainly do not indicate an attitude of laissez faire but rather they show that the managements of these companies are well aware of their responsibilities as good corporate citizens to the community at large.

III RECENT INDUSTRIAL ACTIVITY IN WATER POLLUTION CONTROL

The policy statements quoted above indicate the companies' willingness to co-operate fully with the Ontario Water Resources Commission, their realization of their responsibility in respect to the problem, and their desire to improve water quality.

No matter how well intentioned industry may be in this regard, nevertheless, it is what they have done about the problem which really counts. A review of the activities of the same sixteen companies in their progress towards more effective water pollution control is therefore worthwhile.

Campbell Soup Company Limited

1. Within the last year the company opened a new plant in Listowel, Ontario, for making frozen foods and killing poultry. They worked closely with the Ontario Water Resources Commission to avoid water pollution in the area,

and waste disposal facilities were built exactly in accordance with the Ontario Water Resources Commission's recommendation. They also donated a piece of their property to the Commission to be used as a pumping station for the waste from the Town of Listowel.

2. Last year the company also opened a new soup canning plant at Portage la Prairie, Manitoba. They worked closely with the Province of Manitoba and the consulting engineers for the City to ensure that there would be no contamination in the Assiniboine River. Lagooning installations were made to handle the total sewage load for the entire City. Special arrangements were made in the water piping design of the plant to divert warm cooling water to the lagoon rather than to storm drains, to reduce the period of ice cover and the thickness of the ice on the lagoon.

3. At the present time they are co-operating with the Ontario Water Resources Commission and the City of Chatham in a development of a sewage treatment program to reduce contamination of the Thames River. For two seasons, they have conducted rather extensive surveys of the Thames River contamination. They have employed soil specialists to make a soil survey of the area with a view to spray irrigation and lagooning. The company has co-operated with the City's consulting engineers and Libby, McNeill and Libby Limited, and have jointly recommended a sewage treatment program that will make substantial reductions in the proposed capital expenditure.

4. At the company's main processing plant in New Toronto, they have made a number of recent in-plant changes so that no waste is discharged to the storm drains and, ultimately, Lake Ontario, that has a BOD content or other analyses that are in excess of the figure approved by the Ontario Water Resources Commission for storm drains operation.

Canadian Industries Limited.

1. A large scale biological survey has been carried out in the waters of Lake Ontario since 1956 to monitor the cumulative effect on the lake of waste water coming from two large chemical plants. This survey once detected incipient pollution which was corrected before any damage was done. The results are reported in Sewage and Industrial Waste 31 1383-94 (1959).

2. At one large plant a survey was conducted to find out what pollution problems existed. This was followed by experimental work to find technical solutions to the problems which were discovered. The engineering design work is now being done to specify the equipment to neutralize small quantities of waste acid coming from the Metal Finishing Shop. The necessary equipment will be installed shortly.

3. Another survey was carried out by a Works which indicated that the effluent from that particular plant does not constitute pollution.

4. Engineering design work is in progress to design a process and equipment to prevent pollution from the waste which will result from the manufacture of TNT by a new process.

5. A "Digest of Water Pollution Legislation and Regulations in Force in Canada" has been compiled and distributed to all Company Works with a view to informing the various responsible persons of the nature of Canadian legislation on water pollution.

Canadian Oil Companies Limited

1. Prior to 1956 a bacteriological oxidation unit was installed for phenol removal from the refinery effluent.

2. The Refinery Sewer Systems have been recently renovated, enlarged and changed in detail when a new Crude Unit was built. The Sewer System was changed from two streams (a clean and oily sewer) to three streams, (a clean, oily and potentially oily sewer). The potentially oily sewer is run into an individual Oil Separator prior to flowing to the river. This will remove any oil contamination that might accidentally enter this sewer.

3. The two Oil Separators were altered in flow and one made more efficient by means of mechanical surface skimmers. Former practice was to run the oily water sewer in parallel flow through the two Separators. The practice now is to run the oily water sewer through one Separator equipped with revolving oil skimmers and run the potentially oily water sewer through the other Separator. This method of Separator use results in better oil reclamation as the oily water Separator operates more efficiently as it is not heavily water loaded and in addition has mechanical scrapers. The potentially oily water Separator is operating without oil on its surface (except in emergency) which results in less air pollution due to hydrocarbon evaporation and less pollution of water flowing to the river.

4. Improvements were made to the flue gas stream stripper for phenol removal prior to the Bacteriological Oxidation Unit.

5. Future plans call for:

   a) The installation of a secondary oil recovery down stream from their present Oil Separators in order to remove the last traces of oil from oily sewer effluent.

   b) A study of means of automatic sampling and testing of sewer effluents for phenol and oil contamination.

c) The use of a well into the Detroit Sandstone Stratum for disposal of certain types of waste water.

Cities Service Refining (Canada) Limited

1. Cities Service Trafalgar refinery has been constructed with the most modern and effective water treatment plant. This plant returns water to Lake Ontario purer than when it is withdrawn. To demonstrate to the public and to other industries that there is no longer any need for water pollution in new plants, an aquarium and fountain have been installed which use the purified effluent water from the refinery.

   The cost of these projects was $3,000,000 or one out of every eight dollars spent on the construction of the refinery.

2. The company tries to assist the cause of pollution control by making the public aware of the detrimental effects of pollution caused through lack of control. A continuing program of public education was started three years ago. A speaker has been sponsored; displays have been exhibited; literature has been produced for distribution; and a colour film has been made for exhibition which shows how well the water pollution control at the new Trafalgar refinery works.

3. To further the cause Cities Service has worked with the Ontario Water Resources Commission, the Ontario Department of Planning and Development, Ontario Federation of Naturalists, the Hamilton Naturalists Club, the South Peel Naturalists Club, and the Boy Scouts' Association of Ontario to issue literature, to hold meetings and to stage exhibitions on conservation and water pollution control.

Cyanamid of Canada Limited.

1. Welland Plant - (located near Niagara Falls, Ontario)

   a) An analytical survey is made each month of all water and aqueous effluents and results are reviewed annually with a representative of the Ontario Water Resources Commission.

   b) A new 60 million cubic foot primary sludge settling basin was completed for use in late 1961. This additional facility brings the total settling basin area to 160 million cubic feet.

   c) A secondary refermentation system was installed in the new antibiotic plant to eliminate any discharge of an objectionable deoxygenating waste.

   d) The conversion of the Ammonia Process from coal

to natural gas in 1960 has eliminated the discharge of phenols and cyanides in aqueous effluents.

e) A study has been completed and plans are being made to install an automatic conductivity analyzer system in the discharge sewer from the Ammonium Nitrate Process to assist in the elimination of the loss of a valuable but harmless discharge.

2. Hamilton Bay Plant

Prior to the construction of this Plant, the calculated levels of water pollution were prepared and submitted to Dr. A.E. Berry, General Manager of the Ontario Water Resources Commission, and were approved. The main Water pollutants at the plant are caustic soda, sodium carbonate, monoethanolamine, urea and potassium permanganate. These pollutants have been maintained below the acceptable design limits. Sewer effluent is monitored regularly, and any change in the level of these materials is quickly traced and corrected.

Dominion Magnesium Limited.

Surveys indicate that the effluents from the company's plants do not constitute pollution.

Du Pont of Canada Limited.

1. Prior to start of operations at the new Corunna, Ontario, plant site, conditions in the St. Clair River were established by a biological survey in conjunction with other members of the St. Clair River Research Committee. A further survey is planned as part of a continuing control program. In addition, co-ordinated weekly surveys of the river for phenol and continuous monitoring of the plant effluent for other potential contaminants are carried out.

2. Following seven years of plant operation at the Maitland (Ont.) Works a second full scale biological survey of the St.Lawrence River was carried out in 1960. Results showed no deterioration from the biological healthy condition of the river determined by a survey performed in 1952.

3. At the same plant site a major alteration was completed in 1960. To achieve more efficient dispersion of the high volume of warm service water returned to the river, which was previously released at the shore line, a 5-foot diameter submerged pipe now discharges it at a point 500 feet from shore.

4. A paper describing industrial waste disposal activities at the Maitland site is reported in the proceedings of the 13th Industrial Waste Conference, Purdue University.

5. At Nipissing Works a program of effluent control was undertaken in conjunction with the Philadelphia Academy of Natural Sciences. Since plant start-up in 1957 continuous monitoring of the La Vase River using Catherwood diatometers has indicated no deleterious effect on the river by the plant effluent. It is planned to incorporate some of the unique features of this study in a paper to be published in due course.

H. J. Heinz Company of Canada Limited

1. The company has routinely adopted the practice of fine screening their process waste waters during the times of the year when heavy runs of tomatoes and other vegetables would result in the wastes creating a public nuisance.

2. Recently they have participated, along with the local municipality, in sharing the cost of fees for an outside consultant to survey their joint waste disposal problems, with a view to a new combined waste disposal facility. This plant will be under the sponsorship of the OWRC; and the company is ready to proceed with its share of this project as soon as the public authorities are ready to go ahead.

Imperial Oil Limited

1. Imperial has taken an active part in all phases of water pollution control. Close liaison with regulatory bodies is maintained with a 'cards on the table' relationship. This has resulted in establishing a reputation for integrity. The company has pioneered in several fields of research and application of new concepts of pollution control and has passed on the information to the petroleum industry and other manufacturers by means of technical papers and discussions.

2. Biological oxidation of refinery waste water as a practicable operation was installed after three years of research.

3. Solid waste disposal plants were engineered and built for oil recovery and water clarification. Oil-water separators were improved and redesigned for better operation. Complete treatment of petro-chemical wastes was developed before new plants were built.

4. Co-operative research in water pollution control was pioneered by three Sarnia firms of which Imperial was one. This type of approach enlists the efforts of the technical and scientific staffs of industry, consultants, universities and regulatory groups of government. This practice of co-operation has become popular in many parts of Canada and it has been instrumental in solving several water pollution problems.

Kimberly-Clark Pulp and Paper Company Limited

The activities of Kimberly-Clark in water pollution control have already been reported in some detail at this meeting by Dr. J. R. Rowley. Nevertheless, it is worthwhile to summarize their work here.

1. The company employed a consulting biologist to survey the receiving waters before the mill started up in 1948. His services as a consultant have been retained, and he has made field surveys about every three years since that time.

2. Continuous recording of the flow of mill effluent and automatic sampling of the effluent were included in design of the mill. The only major change in effluent system since that time has been to provide a separate piping system for bleachery effluents. Flow recording and sampling systems were included with that installation.

3. Fullest advantage is taken of a natural waterway (a minor brook, with no fish population) on company property through which mill effluent passes before entering the receiving body of water. Natural ponds have been utilized and kept effective to an extent that removes completely all suspended solids. Natural turbulence is preserved or augmented to assure a substantial reduction in BOD.

4. The company spent $25,000 simply to improve the appearance where the effluent stream passes under the highway.

5. The company has been active in the formation of a group committee on pollution improvement composed of the five sulphate pulp mills in northwestern Ontario.

Libby, McNeill and Libby of Canada Limited.

1. The City of Chatham have employed consulting engineers who have prepared and submitted to the City a plan for sewage disposal that would take care of the entire municipality. Libby, McNeill and Libby has consulted with the City and their consulting engineers, and currently the engineers are considering an alternate plan which the company has suggested to them for taking care of their effluent, and that of one or two other plants, at a cost considerably less than that originally contemplated. It will be several months yet before the alternate plan is worked out, but it is certain that whatever is done will be of a type and capacity to take care of the entire municipality including the company's plant.

2. At the City of Wallaceburg the company has indicated to officials that they will be happy to co-operate with them in whatever scheme is planned for the town.

In the meantime, both plants are keeping the BOD of their

effluent to as low a point as possible by careful screening of the wastes before they are discharged into the sewage system.

The Ontario Paper Company Limited

1. Dissolved Solids Wastes

This includes the waste liquor from the sulphite cooking process. The danger is not one of health but in the reduction of dissolved oxygen leading to septic conditions of the waterway. In spite of ample dilution nearby, the company has put much emphasis on this. A fermentation process was installed in 1943 to remove the fermentable sugars by the production of ethyl alcohol. This was followed in 1952 by a second plant which produced vanillin through the oxidation of lignin in the alcohol plant effluent. In 1959, major changes were made in the latter process which increased the vanillin production and made possible research in the further utilization of the soluble wastes.

A parallel problem is the maximum recovery of the sulphite waste liquors for most economical processing. Work is done on this on a continuing basis.

2. Filterable Solids Wastes

This includes the fines and spillage of paper fibres occurring during the manufacture of the pulp and paper. It also includes fresh water silt and coarse waste arising during wood preparation.

In general, the filterable solids discharged have shown a considerable reduction during the past few years with the present quantity running 50% of the 1950 rate of loss.

A centre has been established for coarse waste removal and work is in progress to improve and make maximum use of these facilities.

While the complete removal of all fines is economically impossible, continual pressure is maintained to close up the system in the mill. This includes the re-use of waste streams where possible and the reduction of accidental or intermittent losses through modifications or improved installations.

Shell Oil Company of Canada Limited.

1. The company is a co-founder of the Laval Industrial Association comprising seventeen industrial concerns in the greater Montreal area devoted to a continuing study of water and air pollution problems. Among the Association's more vital activities at present is a continuing water pollution survey conducted from testing stations at various

points along the St. Lawrence River.

2. In another major Canadian refining area, the company is co-operating with other industrial concerns in a move to encourage the establishment of an organization similar to the Laval Industrial Association in structure and purpose.

3. At one of the company's refineries a flexible, floating spill boom has been installed to contain any accidental spillages of petroleum products in the refinery dock area. A similar device is under construction at another plant.

4. Mechanical "flight scraping" equipment has been installed in API separator basins at the refineries to skim concentrations of oil from the surface of effluent water, thus increasing efficiency of the basins.

5. Facilities for removing oil from tanker ballast water have been installed at refinery shipping points.

6. Equipment for neutralizing small quantities of waste acids has been developed and installed at a chemical plant.

7. Effluent streams from individual process units are monitored on a periodic basis to identify and eliminate pollutants at their source.

A Metal Working Company

The company recently completed a very detailed analysis of the effluent from their plant to the municipal sewage system. From this study figures were obtained indicating the quantity and concentration of the contamination and the relationship it bears to the required standards. A complete report of this study together with two alternative engineering proposals of methods of reducing the contamination has been submitted to the OWRC for their consideration. This report is complete with detail drawings showing the equipment to be used, rates of flow, contamination and cost of installation of equipment.

This survey indicated that their effluent had two major divisions, about equal in flow, one of which easily met the standards of the OWRC and the other which did not. The latter is the one which was considered in the engineering proposals for treatment.

In addition to the above, the company has worked with outside engineering firms in water pollution control to find methods of controlling their effluent and has received two proposals from them.

Steel Company "A"

1. The company recently formed a technical group, headed by an air and water pollution control engineer.

2. This group has carried out an extensive study on water flows in the plant's waste water system and has determined the

quality and quantity of the plant waste water.

3. The engineering design work has been completed on a new Phenol extracting plant to treat the effluent from the coke ovens. Construction on this installation is to be started in the near future and will be completed in 1961 at a cost of $600,000.

4. Experimental work is currently being conducted to increase the efficiency of existing Walker thickner equipment, treating the effluent from Blast Furnace gas washers. Various chemical coagulants are being tried in these tests.

5. A lagoon, with a holding capacity of 12 million gallons has been constructed for the purpose of:

   a) Removing, by settling any mill scale or other suspended solids not removed by existing scale pits.

   b) Removal of any floating oils by a single stage skimmer.

   The Engineering Department is proceeding with the design for the installation of an additional skimmer. This will increase the recovery of waste oils.

6. A close surveillance of all major lubricating systems by the persons in charge eliminates the possibility of large spills of oil being discharged to the plant waste water system. This is possible by the early detection of any breaks in the lubrication lines. Lubricating oil tanks are frequently gauged and any abnormal drop in the oil level is immediately investigated.

Steel Company "B"

1. During the last two to three years the most significant achievement of the company to decrease river pollution has been the recovery of iron bearing flue dust originating from the blast furnace operations. The installation of a new Gas Cleaning Plant complete with Dorr Thickener, vacuum filter drums and venturi washers has made it possible to control the discharge water within the International Joint Commission's limits for iron content.

2. Numerous plant surveys have and are being made to determine the best method of controlling sanitary sewage and Coke Plant effluents. To date none of the surveys have produced a method completely acceptable to year round operations. A firm of consulting engineers will be engaged this summer to survey the Plant and recommend the most practical means of treating the sanitary sewage.

   At the moment engineering drawings of a combination oil

and mill scale separating basin to improve the quality of the water discharge from their Hot Strip Mill are awaiting final approval. In the meantime daily chemical analyses are being made of the Plant effluents and surveys of the receiving body of water are continuing as they have been since 1956.

SUMMARY AND CONCLUSIONS

1. Industry wants the provincial control agencies to be well run by competent people who will consider all aspects of the problem before arriving at a decision.

2. Industry's policy on water pollution control is in accord with the Objectives of the Ontario Water Resources Commission and industrial firms intend to work steadily to improve water quality to the required standards.

3. The record shows that in recent years industry has devoted considerable time, money and effort in installing suitable apparatus for water pollution control and that industrial effluents are indeed rapidly approaching the Objectives of the Ontario Water Resources Commission.

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